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List of Acronyms and Abbreviations

BECC	Border Environment Cooperation Commission
BEIF	Border Environmental Infrastructure Fund
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CCN	Certificate of Convenience and Necessity
CEAT	Comisión Estatal del Agua de Tamaulipas
CILA	Comisión Internacional de Límites y Aguas
COCEF	Comisión de Cooperación Ecológica Fronteriza
COMAPA	Comisión Municipal de Agua Potable y Alcantarillado
CONAGUA	Comisión Nacional del Agua
CRP	Clean Rivers Program
CWA	Clean Water Act
DO	dissolved oxygen
DPRP	Danube Pollution Reduction Program
EDAP	Economically Distressed Areas Program of Texas
EPA	United States Environmental Protection Agency
EPWU	El Paso Water Utilities
EU WFD	European Union Water Framework Directive
FY	fiscal year
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GEF	Global Environment Facility
IBWC	International Boundary and Water Commission
ICPDR	International Commission for the Protection of the Danube River
IMTA	Instituto Mexicano de Tecnología del Agua
JAD	Water and Wastewater Board
JPAC	Joint Public Advisory Committee
LBJ School	Lyndon B. Johnson School of Public Affairs
LUPE	La Unión del Pueblo Entero
LVBC	Lake Victoria Basic Commission
LVEMP	Lake Victoria Environmental Management Project
MRC	Mekong River Commission
NACEC	North American Commission on Environmental Cooperation

NADB	North American Development Bank
NAFTA	North American Free Trade Agreement
NGO	Non-governmental Organization
NORAD	Norwegian Agency for Development Cooperation
NPDES	National Pollutant Discharge Elimination System
OAG	Office of Attorney General
PDAP	Project Development Assistance Program
PRP	Policy Research Project
RGRWA	Rio Grande Regional Water Authority
RPG	Regional Public Good
SADC	South African Development Council
SAP	Strategic Action Plan
SDWA	Safe Drinking Water Act
SEDUMA	Secretario de Desarrollo Urbano y Medio Ambiente
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
SIDA	Swedish International Development Cooperation Agency
TCEQ	Texas Commission on Environmental Quality
TCWA	Texas Clean Water Act
TLAP	Texas Land Application Permit
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
US	United States
USD	United States dollars
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USIBWC	International Boundary and Water Commission, US Section
UT/Austin	The University of Texas at Austin
WWF	World Wildlife Fund
WWTP	Wastewater treatment plant
ZAMCOM	Zambezi Watercourse Commission

Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month Policy Research Project (PRP) course, in which faculty members from different disciplines direct the research of ten to thirty graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency. This "client orientation" brings the students face to face with administrators, legislators, and other officials active in the policy process and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of political realities.

During the 2011-2012 and 2012-2013 academic years, 42 students participated in the Lower Rio Grande Water Quality Initiative, a Policy Research Project working with Mexican, Texas, U.S., and bilateral institutions to identify options for improving the water quality within segments 2301 and 2302 in the Rio Grande/Río Bravo that define the Texas/Mexico border below the Falcon Reservoir. The river appears on many "worst U.S. river" lists because the water quality in some segments does not meet Mexican, Texas, or U.S. ambient water quality criteria, in part because it is one of the most over-appropriated rivers in the U.S. As the Rio Grande/Río Bravo is a border river, neither the U.S./Texas alone nor Mexico alone can control water quality.

Student participants conducted research on regional water quality uses and what can be done to improve water quality, conducted interviews among stakeholders, surveyed water users and river basin residents, and recorded video of stakeholders' views and water infrastructure in the region. This report documents water users' perceptions of river water quality and their preferences to improve water quality to enable the river to return to its role as a regional resource for fishing, swimming, and other recreation, as well as continue to be a source for domestic drinking water, irrigation, commercial water use, and industrial development.

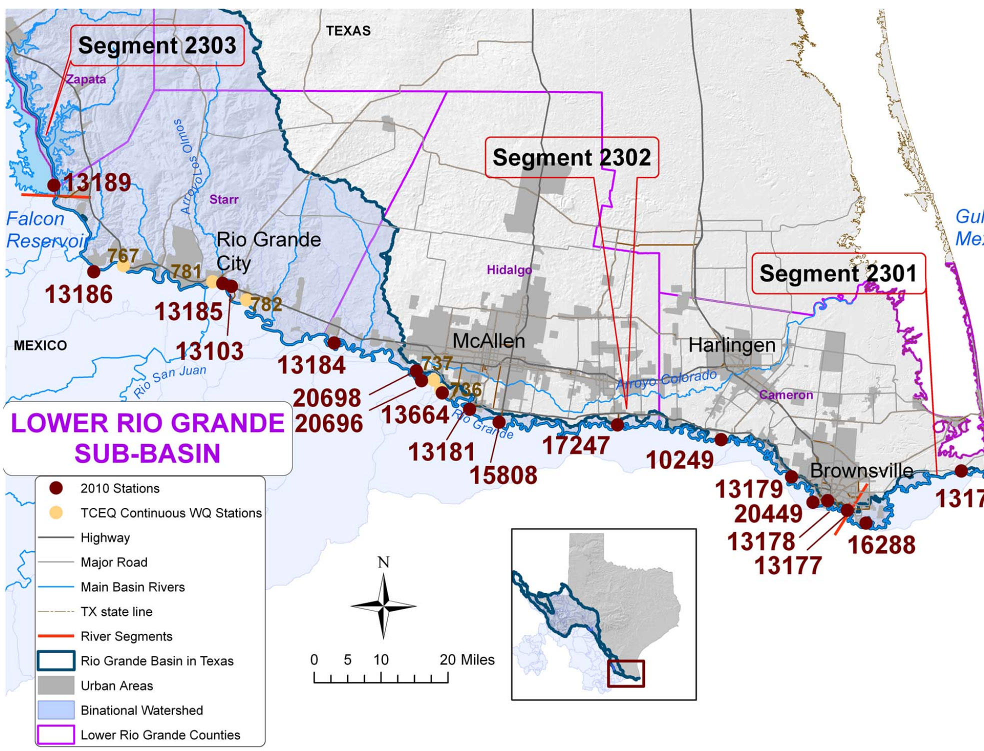
The curriculum of the LBJ School is intended not only to develop effective public servants but also to produce research that will enlighten and inform those already engaged in the policy process. The project that resulted in this report has helped to accomplish the first task; it is our hope that the report itself will contribute to the second. Finally, it should be noted that neither the LBJ School nor The University of Texas at Austin necessarily endorses the views or findings of this report.

Robert Hutchings
Dean
LBJ School of Public Affairs

Chapter 1. Introduction

According to the UN's Water for Life website, 263 water bodies span international borders, many of which form the boundary between two or more nations; nearly 150 countries share international river or lake watersheds.[1] This introductory chapter reports on ideas that could assist in the development of plans to improve water quality in the Rio Grande/Río Bravo based on two sources of information: the professional literature on trans-boundary water management and the track-record of nations seeking to improve water quality across national borders. The remainder of the chapter describes the area of focus for this study, the region on the Texas-Mexico border shown in Figure 1.1. The Lower Rio Grande/Río Bravo, the land between the Falcon Reservoir and the Gulf of Mexico, along 450 kilometers or 270 miles, is shared between the states of Texas and Tamaulipas.[2]

Figure 1.1 The Lower Rio Grande/Río Bravo



Source: International Boundary and Water Commission, Texas Clean Rivers Program, Map of Lower Rio Grande/Río Bravo, available at http://www.ibwc.state.gov/CRP/images/maps/Basin-BHRFigureLower.jpg.

Research Literature on Transboundary Water Management

Analysts have written many professional articles to identify principles to improve transboundary water management and it is beyond the scope of this chapter to review this diverse and rich literature. Table 1.1 lists some barriers to cooperative management for improving water quality and steps that could improve cooperation found in the literature.

Table 1.1 Transboundary Water Quality Management Principles

Barriers to Transboundary Water Cooperation: • Power asymmetries • Different political systems, legal systems and/or institutional structures • Differences in access to investment and capital flows • Different levels of infrastructure development • Conflict and violence • The absence of regional cooperative frameworks or transboundary water institutions • Demographic differences • Historical conflict • Limited nation-state capacity to manage water resources or cooperate effectively
Techniques for Overcoming Barriers to Cooperation: • Public advice and representation from stakeholder mediation • Map the range of divergent issues • Identify positive sum opportunities • Local solutions, facilitation and leadership • Develop a common vision • Joint fact finding • Determining and presenting scientific data • Transparency and information exchange • Make solutions equitable • Do no harm • Commit to notify, consult and negotiate • Build up the political and economic capacity of the inferior party • Conflict resolution techniques

Zeitoun and Jagerskog identify "power asymmetry" as a barrier to transboundary cooperation in the Tigris, Mekong, Ganges, Nile and Jordan Rivers.[3] They argue that one party may benefit more than another if transnational cooperation takes place within the context of economic inequity and power asymmetries. They report that power asymmetries can be influenced through the identification of positive sum opportunities or through international diplomacy and the presence of independent mediators. They argue that power asymmetries can be reduced by building up the political and economic capacity of the inferior party or through binding multilateral negotiations and mediation. They cite Turkish dam building projects on the Tigris and Chinese projects on the Mekong River as examples where stronger upstream nations have controlled water resources of downstream neighbors.

Grey, Sadoff, and Connors outline a model of "benefit sharing" that builds from case studies from the Senegal, Columbia, Nile and Ganges rivers.[4] They indicate that long-term donor commitment in combination with a local understanding of potential benefits can further the cooperative process. Granit and Claasen argue that diverse stakeholders can identify potential benefits and opportunities within a body of water that can bring potential economic, environmental and social benefits to the forefront within transboundary initiatives.[5] Mehyar, al Khateeb and Bromberg note that the cooperation among Jordanian, Israeli, and Palestinian communities aimed at improving the quality and quantity of water in the Jordan River can be used as an example of cooperative action within a contentious political environment.[6] This model of "environmental peacekeeping" draws its strength from local level community cooperation that then resonates along national lines.

Experiences in Transboundary Water Quality

Project members reviewed the International Freshwater Treaties Database located at the website of the Oregon State University Program in Water Conflict Management and Transformation that catalogues over 400 international treaties, protocols, and agreements concerning the use, allocation, and stewardship of transnational streams and lakes.[7] The study team identified 90 agreements in which water quality cooperation was mentioned as a component activity. Project staff compiled a database of key information on water quality agreements, such as a summary of the agreement, cooperative actions undertaken, possible relevance to the Rio Grande/Río Bravo, and stakeholder involvement (see Appendix B). The following is a discussion of the ideas from the trans-boundary water quality database that could have applicability for transboundary water quality improvement within the Rio Grande/Río Bravo.

While the number of transboundary water treaties and agreements are extensive, the number of treaties that address transboundary water quality issues is limited. Most transboundary river treaties are negotiated agreements on boundary disputes, water allocation, fishing, flood control, irrigation, hydro-electric power, or navigation of shared water. Among the transboundary water quality cases there are even fewer successful examples where two or more nations are planning and implementing water quality improvements together.

Few if any of the cases described below provide a ready-made blueprint for the successful implementation of long-term joint transboundary water quality improvements along the lower Rio Grande/Río Bravo from the Falcon Reservoir to the Gulf of Mexico. The most common levels of bi-national joint effort rely solely on communication and unilateral cooperation, where bordering nations seek to improve water quality by informing each other through independent efforts.

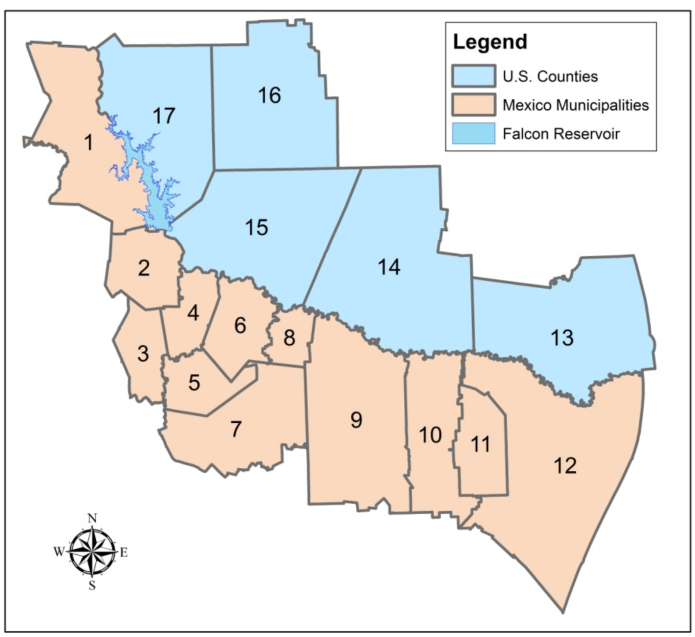
Project members selected eight case studies from different nations for detailed investigation regarding cooperative water quality management efforts. The case studies selected are located in basins shared among 54 countries, including the Danube, Lempa, Mekong, Missisiquoi Bay, Nile, Zambezi, Colombia and Rhine. Cooperative transboundary water quality actions within each basin are described in greater detail in Appendix B.

As a result of this literature review, PRP participants have sought to understand the special attributes of the people and water quality along the Rio Grande/Río Bravo. These elements are discussed below.

The Lower Rio Grande / Río Bravo Water Quality Initiative

The governments of Mexico and the United States have sought for decades to improve the water quality within the lower segment of Rio Grande/Río Bravo, the river that forms their boundary for 270 miles (450 kilometers). The United States and Mexico share responsibility for sanitation within the Rio Grande/Río Bravo because they each have adopted international treaties and agreements to do so, as neither party can control, on its own, the volume of flow or quality of the river. Since 2005, the federal and state environmental agencies in both the U.S. and Mexico have sought to initiate the Lower Rio Grande/Río Bravo Water Quality Initiative (the Initiative), a binational pilot project to restore and protect the quality of the Rio Grande/Río Bravo. Figure 1.2 displays the counties and municipalities in the study area, labeled from 1 to 17 (in counterclockwise order) within the study area.[8]

Figure 1.2 U.S. Counties and México Municipalities in Study Area

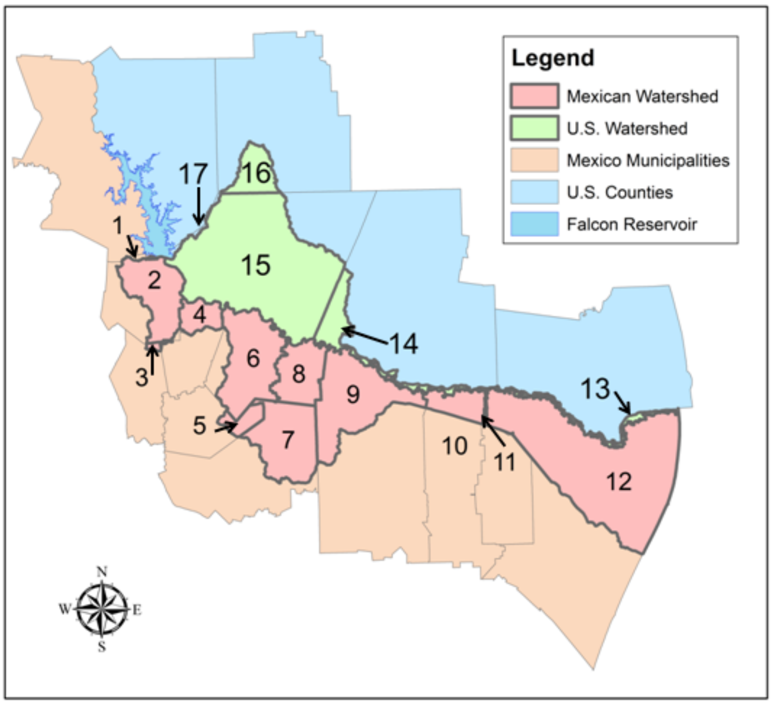


Source: INEGI, "Áreas Geoestadísticas Municipales," Marco Geoestadístico Municipal 2009 Versión 4.1, GIS Shapefile, available at http://mapserver.inegi.org.mx/data/mgm/; U.S. Census Bureau, 2010 TIGER/Line® Shapefiles, November 30, 2010, GIS Shapefile, available at http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html. Map created by Robin Lynch.

Municipalities and Counties of the Study Area

The study area, the 270 miles (450 kilometers) of the Rio Grande/Río Bravo between the Falcon Reservoir and the Gulf of Mexico, falls within the Gulf Coastal Plain. Within each Mexican municipality or U.S. county there is a portion of the land within the watershed boundaries and another fraction of land outside the official river basin limits.[9] Figure 1.3 illustrates how each municipality and county lies relative to the watershed, as the political boundaries do not line up exactly with the watershed boundaries.

Figure 1.3 Municipalities and Counties in the Study Area



Source: INEGI, "Áreas Geoestadísticas Municipales," Marco Geoestadístico Municipal 2009 Versión 4.1, GIS Shapefile, available at http://mapserver.inegi.org.mx/data/mgm/; U.S. Census Bureau, 2010 TIGER/Line® Shapefiles, November 30, 2010, GIS Shapefile, available at http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html. Map created by Robin Lynch.

Table 1.2 lists the areas within the watershed for each numbered Mexican municipality and Texas county, the total area of each municipality or county, and the percentage of the area of each municipality and county in the watershed.[10] The total area of the watershed is 9,682 square kilometers (km^2). The Mexico side of the watershed makes up 6,491 km^2 (67 percent of the watershed) and the U.S. side of the watershed makes up 3,191 km^2 (33 percent of the watershed).[11]

Table 1.2 Watershed Characteristics with Texas and Mexico

Number	Municipality/County	State	Area in Watershed (km^2)	Total Area (km^2)	% of Area in Watershed
1	Guerrero	Tamaulipas	3	2,442	0.1%
2	Mier	Tamaulipas	559	923	60.6%
3	Los Aldamas	Nuevo León	16	695	2.2%
4	Miguel Alemán	Tamaulipas	194	639	30.3%
5	Doctor Coss	Nuevo León	125	721	17.4%
6	Camargo	Tamaulipas	790	930	84.9%
7	General Bravo	Nuevo León	704	1,889	37.3%
8	Gustavo Díaz Ordaz	Tamaulipas	432	432	99.9%
9	Reynosa	Tamaulipas	942	3,147	29.9%
10	Río Bravo	Tamaulipas	235	1,584	14.8%
11	Valle Hermoso	Tamaulipas	11	900	1.2%
12	Matamoros	Tamaulipas	2,481	4,633	53.5%
13	Cameron	Texas	105	3,306	3.2%
14	Hidalgo	Texas	352	4,100	8.6%
15	Starr	Texas	2,468	3,183	77.5%
16	Jim Hogg	Texas	264	2,943	9.0%
17	Zapata	Texas	2	2,740	0.1%

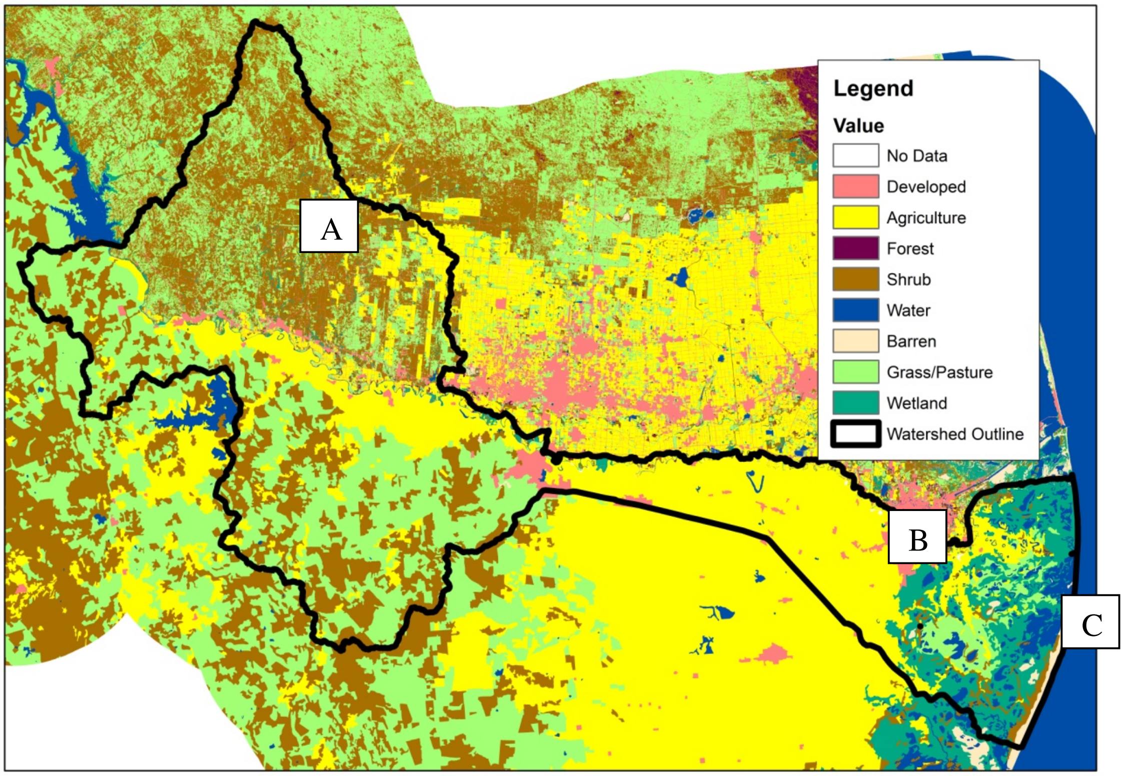
Source: INEGI, "Áreas Geoestadísticas Municipales," Marco Geoestadístico Municipal 2009 Versión 4.1, GIS Shapefile, available at http://mapserver.inegi.org.mx/data/mgm/; U.S. Census Bureau, 2010 TIGER/Line® Shapefiles, November 30, 2010, GIS Shapefile, available at http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html. Table created by Robin Lynch.

The western half of the watershed (labeled A in Figure 1.4) is mostly shrub and grassland used for livestock grazing. The eastern part of the watershed (labeled B in Figure 1.4) is farmed intensively on both the Mexican and U.S. sides. The far eastern part of the watershed (labeled C in Figure 1.4) includes wetlands and water used by wildlife, such as a large number of migratory waterfowl.

Table 1.3 indicates the area in km^2 for each land use within the watershed. The land use with the largest percentage of area in the watershed is grass or pasture, which covers 30.5 percent of the watershed with 2,948 km^2. The second most prominent land use is shrub, which covers 27.4 percent of the watershed with 2,656.50 km^2. These two land uses are mostly in the western part of the watershed, labeled as A in Figure 1.4. The third most prominent land use is agriculture, which covers 25.7 percent of the watershed with 2,493.1 km^2. Water makes up 2.9 percent of the watershed with 278.91 km^2, which accounts for the many rivers and streams throughout the watershed.[12]

Despite the fact that rural areas predominate in segments 2301 and 2132 (shrub, grassland, wetlands, and water), the majority of the 2.5 million people in the region live within urban areas within the four Texas border counties and the eight Tamaulipas municipalities.[13] Comparisons between U.S. and Mexican census data are difficult to make because the two countries collect different demographic data. The total population for the four counties on the U.S. side is 1,203,123 and the total population for the eight municipalities within the area of study on the Mexican side is 1,341,998, making nearly a 50-50 split in overall population for the binational area.

Figure 1.4 Land Use/Land Cover for the Watershed



Source: U.S. Geological Survey, Land Use/ Land Cover: Binational 2001, U.S.-Mexico Border Environmental Health Initiative – Available Data Layers, available at http://txpub.usgs.gov/BEHI/Data_download/LULC/bin2001f.zip, Raster file, accessed July 20, 2011. Map created by Robin Lynch.

Table 1.3 Watershed Land Use

Land Use	Km^2	Percentage
Developed	407.88	4.2%
Agriculture	2,493.01	25.7%
Forest	13.39	0.1%
Shrub	2,656.50	27.4%
Water	278.91	2.9%
Barren	79.71	0.8%
Grass/ Pasture	2,948.45	30.5%
Wetland	793.79	8.2%
No Data	10.71	0.1%
Total	9,682.34	100.0%

Source: Land Use/ Land Cover: Binational 2001, U.S.-Mexico Border Environmental Health Initiative – Available Data Layers, available at http://borderhealth.cr.usgs.gov/datalayers.html, Raster file, accessed July 20, 2011. Table created by Robin Lynch.

Texas Border Country Demographics

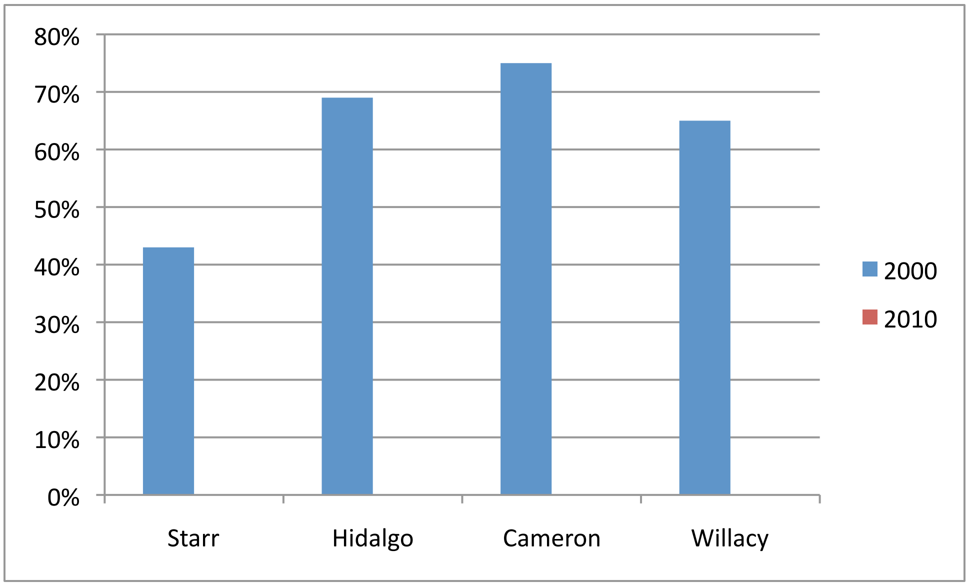
The majority of the four Texas border counties (Starr, Hidalgo, Cameron, and Willacy) either lie within the Rio Grande's Segment 2302 watershed or within water service areas that rely on the Rio Grande as a water source. These four counties, with a growing population of now more than 1.2 million persons, both share common characteristics and exhibit demographic differences (see Figure 1.5). Between 2000 and 2010, the total population of Starr, Hidalgo, Cameron, and Willacy counties increased by 29.2 percent from 978,369 to 1,264,091 (see Table 1.4). Hidalgo County is the most populated county with 774,769 inhabitants (in 2010), or 61.3 percent of the four-county population. Starr County, to the northwest of Hidalgo and the county with by far the most land area within Segment 2302, contributed only 4.8 percent of the four-county population. Hidalgo County is also the fastest growing county. Between 2000 and 2010, Hidalgo's population increased by 36.1 percent, whereas Willacy to its north only grew by 10.2 percent.[14]

Table 1.4 Texas Population Increase by County

	Starr	Hidalgo	Cameron	Willacy	Total
Census 2000**	53,597	569,463	335,227	20,082	978,369
Census 2010*	60,968	774,769	406,220	22,134	1,264,091
Percent Increase	13.75%	36.05%	21.18%	10.22%	29.20%

Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

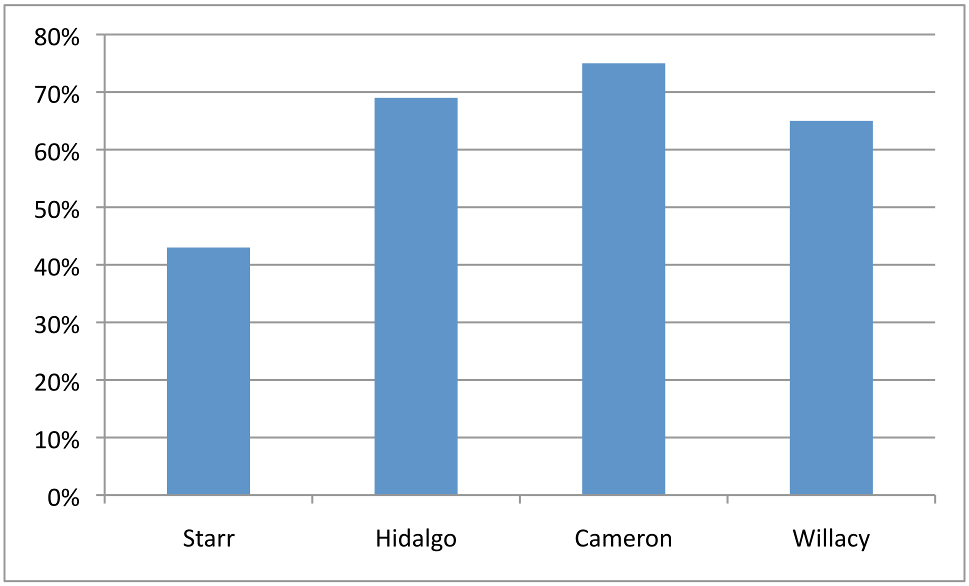
Figure 1.5 Texas Border County Populations



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

The counties' differences relate to population size and population density. Hidalgo County's population is nearly 13 times greater than Starr County. About 70 percent of people in Hidalgo County live in cities or towns, whereas in Starr County that figure is just over 40 percent (see Figure 1.6). Hidalgo, Cameron, and Willacy counties account for 1,203,123, or about 95 percent of the four county areas.[15] There is a difference in the total number of water users who live outside the Segment 2302 watershed within each county versus those who live within its bounds. No one who resides within Willacy County lives within Segment 2302 and only a small fraction of Cameron and Hidalgo are within the watershed, even though their residents routinely use Rio Grande water.

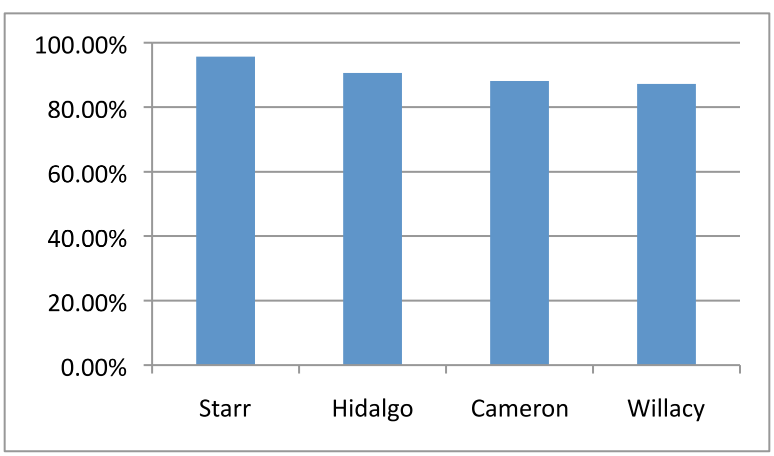
Figure 1.6 Urban Population by Texas Counties



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

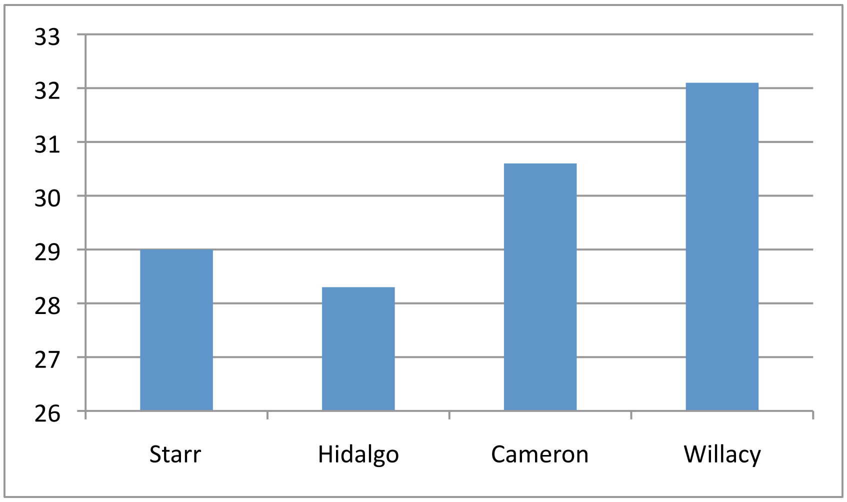
The population of all four counties is predominantly Hispanic, ranging from 87.29 percent and well up to 95.7 percent for Starr County (see Figure 1.7). The population is young, with the median age for each county well below the national average of 37.2 (see Figure 1.8). For example, Hidalgo County's median age is 28.3. One third of the population of Cameron, Hidalgo, and Starr are under 18 (see Figure 1.9). The region is poor as half of everyone under 18 years old lives in poverty (as defined by the U.S. government). The median income in Starr County is only $22,418.[16]

Figure 1.7 Hispanic Population by County



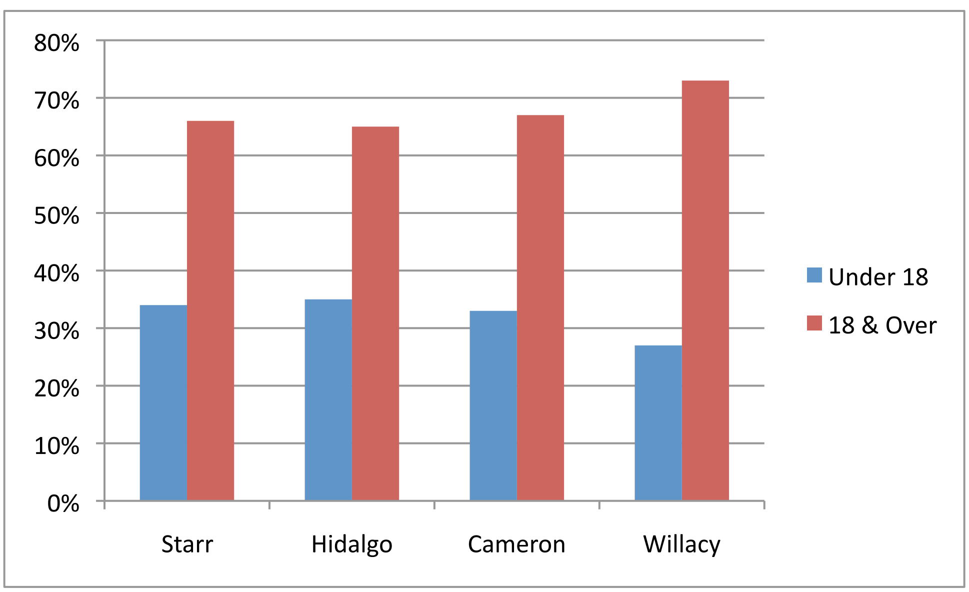
Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

Figure 1.8 Median Resident Age by Texas County



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

Figure 1.9 Resident Age by County

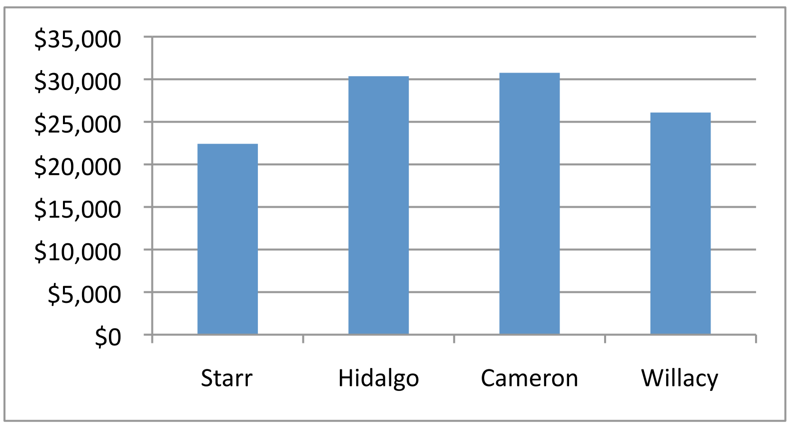


Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

Hidalgo, Cameron, and Willacy Counties are similar with respect to the percentage of the population living in cities or towns. In 2010 Cameron had the greatest population density with 75 percent of the population in urban areas. In Starr County only 43 percent of its people live in cities and towns, mainly along the Rio Grande.[17] In Hidalgo County, the largest population centers are clustered around McAllen, Edinburg, Mission, and Pharr. Cameron County, Brownsville and Harlingen make up the greatest part of the city and town population. In Starr County, most of the "urban" population lives in Rio Grande City and Roma. In Willacy County about half the population is in Raymondville, with the most of the rest distributed throughout the county.

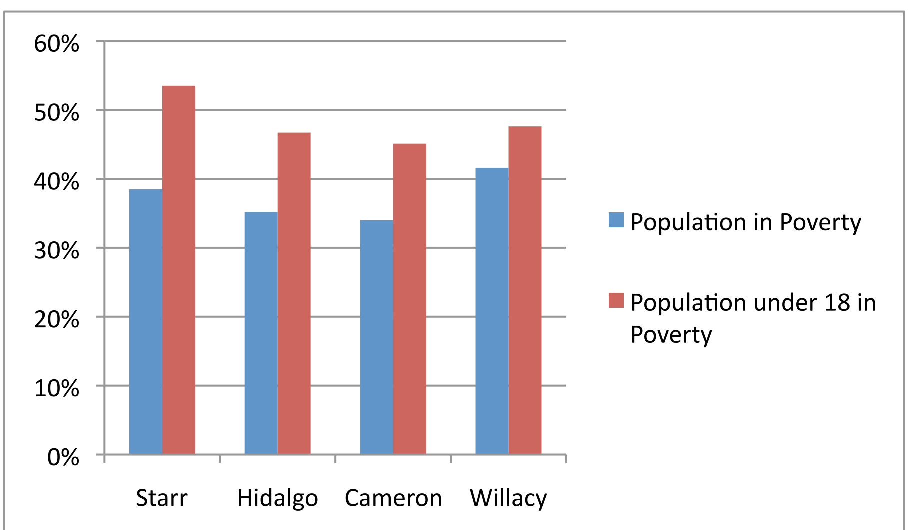
The median income for each of four counties ranges from $22,418 for Starr County to $30,760 for Cameron County (see Figure 1.10). The percent of the population living in poverty in the four counties is especially high for people under 18 with a rate exceeding 50 percent in Starr County (see Figure 1.11). The other three counties are just under 50 percent for people under 18. For the total population the poverty rates are not much better. In Willacy County, 41.6 percent of the people live in poverty, according to 2009 Census data.[18]

Figure 1.10 Median Income by Texas County



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

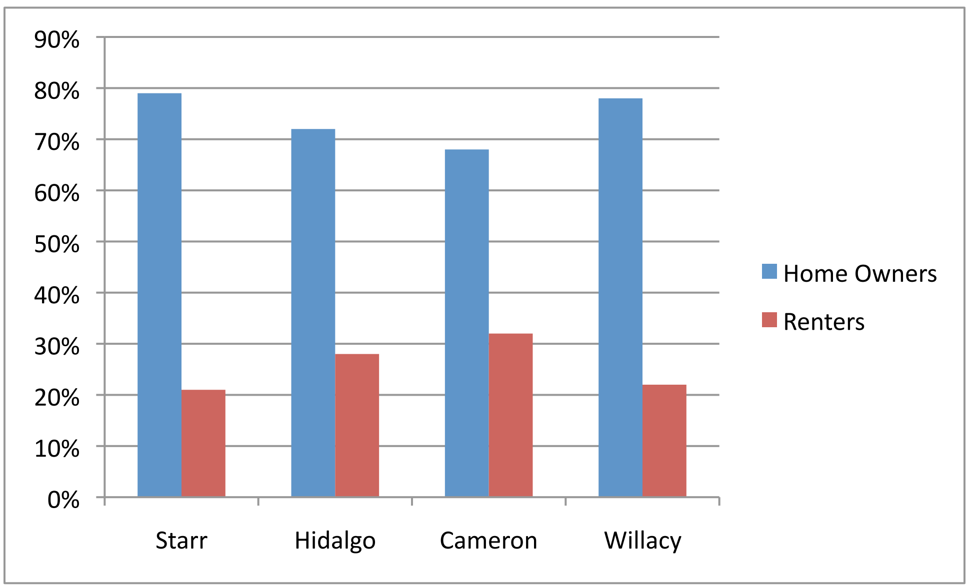
Figure 1.11 Population in Poverty by Age and by Texas County



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

Despite the poverty, over two-thirds of residents live in owner-occupied homes, as opposed to being renters (see Figure 1.12). In Starr, Hidalgo, and Cameron counties one-third of the population is under 18 years old. The majority of the population in the four counties live in owner-occupied housing. The less populated, more rural Starr County has the highest portion of people (79 percent) living in owner-occupied homes. Willacy County, the least populated, has a similar percentage (78 percent). A greater portion of people living in the Hidalgo and Cameron Counties live in housing that is rented.

Figure 1.12 Home Owners/Renters by Texas County



Source: U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

The Texas Secretary of State's web site maintains a Directory of Texas *colonias* located in Texas that "features a listing of all colonias (and their state issued ID number) located in a county in which any part of that county is within 150 miles of the Texas-Mexico border."[19] The directory lists 942 colonias in Hidalgo County, 257 in Starr County, 195 in Cameron County, and only 16 in Willacy County.

Mexico Border Town Demographics

Mexico does not have a county system of local government, as the *municipio*, or municipality, is the political subdivision below the level of state. Eight municipios that border the Rio Grande/Río Bravo are within the area of study in Tamaulipas: from east to west they are Matamoros, Valle Hermosa, Río Bravo, Reynosa, Gustavo Diaz Ordaz, Camargo, Miguel Aleman, and Mier.

Population centers on the Mexican side of the Rio Grande within the area of study include Matamoros, Valle Hermosa, Río Bravo, Reynosa, and several smaller municipios: Gustavo Diaz Ordez, Camargo, Miguel Aleman, and Mier. The total population for these cities in 2010 was 1,341,998. Reynosa, with a population of 608,891, accounts for 45 percent of this total, while Matamoras at 489,193, comprises 36 percent (see Table 1.5). The least populated municipios, Gustavo Diaz Ordaz, Camargo, Miguel Aleman, and Mier, between Reynosa and Lake Falcon, together comprise only 4.7 percent of total area population.[20]

Table 1.5 Tamaulipas Border Municipio Populations

Municipio	2010 Population	Percent of Total
Camargo	14,933	1.1%
Gustavo Diaz Ordaz	15,775	1.2%
Matamoros	489,193	36.5%
Mier	4,762	0.4%
Miguel Aleman	27,015	2.0%
Reynosa	608,891	45.4%
Río Bravo	118,259	8.8%
Valle Hermosa	63,170	4.7%
Total	1,341,998	100%

Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

Table 1.6 Tamaulipas Border Municipio Private Dwellings

Municpio	Private Dwellings	Percent of Total
Matamoros	133,116	36.0%
Valle Hermosa	17,399	4.7%
Río Bravo	31,371	8.5%
Reynosa	170,171	46.0%
Gustavo Diaz Ordaz	4,593	1.2%
Camargo	4,403	1.2%
Miguel Aleman	7,583	2.0%

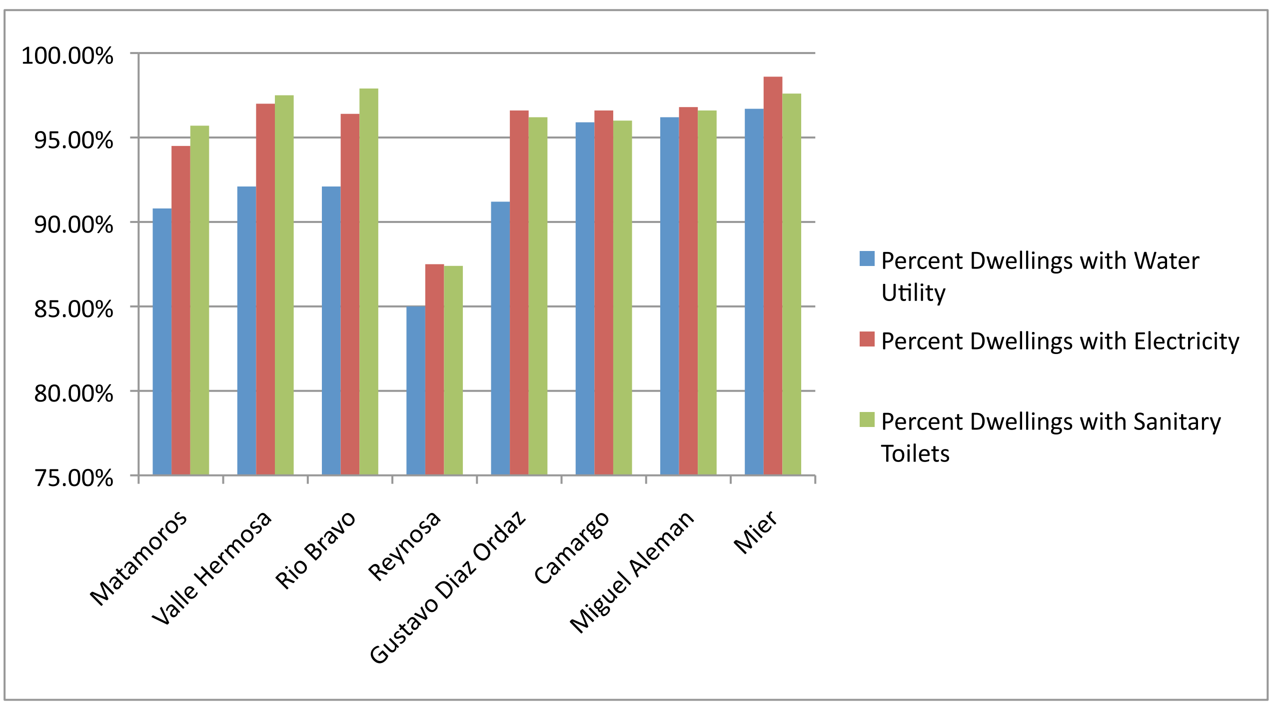
Mier	1,442	0.4%
Total	370,078	100.0%

Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

The population in each municipio correlates to the number of private dwellings in each (see Table 1.6). For example, the Reynosa municipio population accounts for 45.4 percent of the population in this area and Reynosa includes 46 percent of the private dwellings.

There are differences between the eight municipios with respect to some of the private dwelling characteristics. As illustrated in Figure 1.13 and Table 1.7, the percent of private dwellings per municipio with a public water supply ranges from 85.0 percent to 96.7 percent, the percent with electricity ranges from 87.5 percent to 98.6 percent, and the houses connected to sewage collection and treatment range from 87.4 percent to 97.6 percent.[21] The private dwelling data shows that the two most populated municipios, Reynosa and Matamoras, have the lowest percentages for piped water supplies, electricity, and sewage collection and treatment. For example, the number of people in Reynosa without access to a public sewer system or wastewater treatment is estimated to be 12.5 percent of inhabitants, or 81,478. In other words, in Reynosa 15.0 percent of the private dwellings *do not have* a water utility connection, 12.5 percent *do not have* electricity, and the waste of 12.6 percent of the population *do not flush to an indoors toilet connected to a sewer*. In real numbers, of Reynosa's 170,171 private dwellings, an estimated 21,440 homes do not have access to a sewer system.[22]

Figure 1.13 Mexican Municipio Private Dwellings Utilities



Source: I NEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

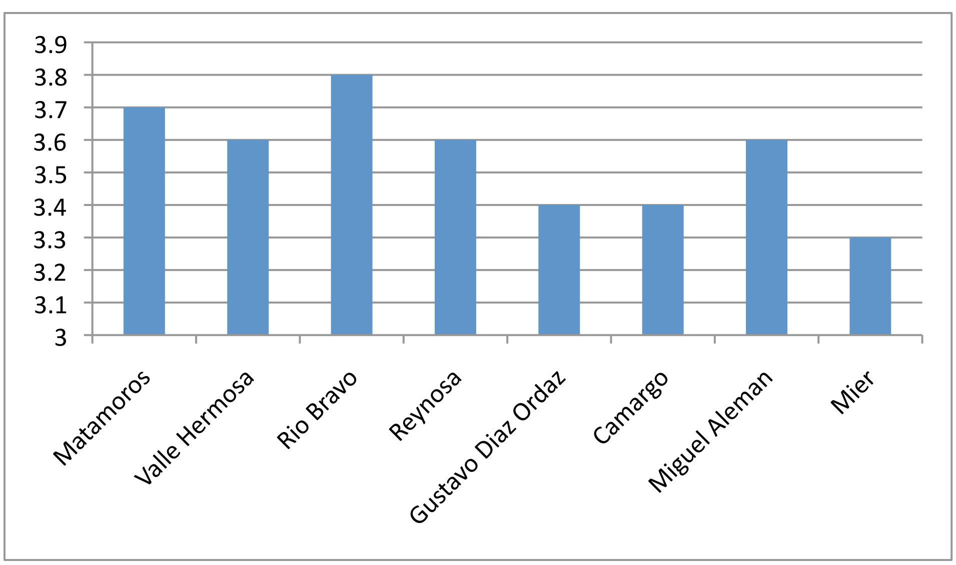
Table 1.7 Mexican Municipio Private Dwellings with Utilities

Municipio	Percent Dwellings with Water Utility	Percent Dwellings with Electricity	Percent Dwellings with Sanitary Toilets
Matamoros	90.8%	94.5%	95.7%
Valle Hermosa	92.1%	97.0%	97.5%
Río Bravo	92.1%	96.4%	97.9%
Reynosa	85.0%	87.5%	87.4%
Gustavo Diaz Ordaz	91.2%	96.6%	96.2%
Camargo	95.9%	96.6%	96.0%
Miguel Aleman	96.2%	96.8%	96.6%
Mier	96.7%	98.6%	97.6%

Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

Another difference among municipios is the average household size, where the average ranges from 3.3 people per household in Mier to 3.8 for Río Bravo (see Figure 1.14). The average household size does not seem to correlate to municipio population or private dwelling characteristics. Reynosa's average household size is 3.6. Based on that figure, it is estimated that 81,478 people in Reynosa live in dwellings without access to a piped sewer system.

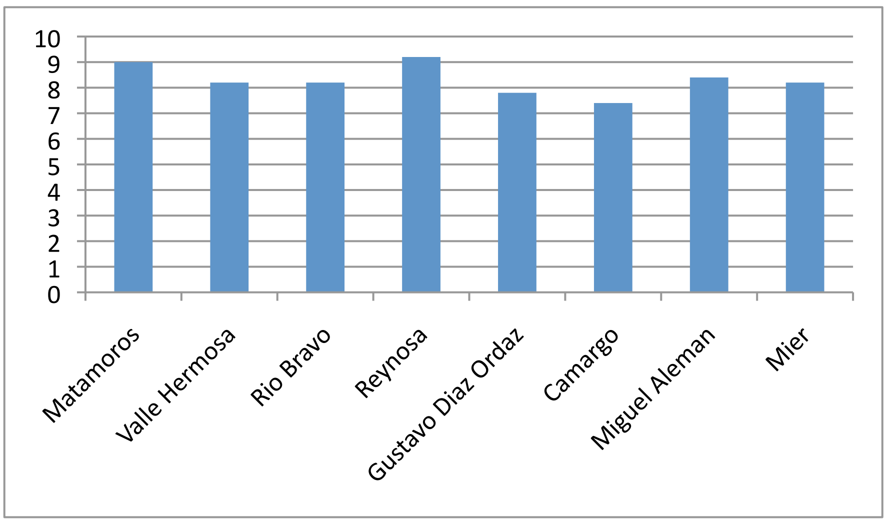
Figure 1.14 Mexican Municipio Household Size



Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

Education attainment levels vary among the eight Mexican municipios. The Mexican Census Agency (INEGI) collects the average 'grade level' when citizens end their schooling (for the population 15 and over). These averages range from grades 7.4 to 9.4 (see Figure 1.15). The more populated municipios (Reynosa and Matamoras) have the highest grade completion level (at 9.2 and 9.0, respectively). The lowest levels for grade completion, Carmago at 7.4 and Gustav Diaz Orden at 7.8, are among the municipios that are least populated.[23]

Figure 1.15 Mexican Municipio Education Attainment



Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

Note: Vertical numbers indicate average grade attainment in the population 15 and over in 2010.

The male to female ratio does not vary much among municipios. The percent female ranges from 49.4 percent in Gustavo Diaz Ordaz to 50.8 percent in Valle Hermosa, or a 1.4 percentage point spread (see Table 1.8).

Table 1.8 Mexican Municipio Population Distribution by Gender

Municipio	Percent Male	Percent Female
Matamoros	49.5%	50.5%
Valle Hermosa	49.2%	50.8%
Río Bravo	50.0%	50.0%
Reynosa	49.9%	50.1%
Gustavo Diaz Ordaz	50.6%	49.4%
Camargo	50.7%	49.3%
Miguel Aleman	49.9%	50.1%
Mier	49.3%	50.7%

Source: INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

This first chapter has described the population characteristics of the Lower Rio Grande Basin. Chapter 2 reports on the water quality management institutions of Mexico and the U.S. that seek to improve water quality in the river.

Endnotes

[1] Transboundary Waters, Water for Life, 2005-2015, accessed 8 October 2011, available at http://www.un.org/waterforlifedecade/transboundary_waters.shtml.

[2] Parcher, Sean W., Dennis G. Woodward and Roger A. Durall, "A Descriptive Overview of the Rio Grande-Rio Bravo Watershed," *Journal of Transboundary Water Resources*, 2010, 159-177.

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[8] Instituto Nacional de Estatistica y Geografía (INEGI), "Areas Geoestadfsticas Municipales," Marco Geoestadfstico Municipal 2009 Versi6n 4.1, GIS Shapefile, available at http://mapserver.iuegi.org.mx/data/mgm/; U.S. Census Bureau, "2010 TIGER/Line® Shapefiles," GIS Shapefile, available at http://www.census.gov/geo/www/tiger/tgrshp20_I O/tgrshp20 l O.htrnl, November 30, 2010.

[9] INEGI, "Areas Geoestadfsticas Municipales"; U.S. Census Bureau, "2010 TIGER!Liue® Shapefiles," November 30, 2010.

[10] Ibid.

[11] INEGI, "Áreas Geoestadísticas Municipales," Marco Geoestadístico Municipal 2009 Versión 4.1, GIS Shapefile, available at http://mapserver.inegi.org.mx/data/mgm/; U.S. Census Bureau, 2010 TIGER/Line® Shapefiles, November 30, 2010, GIS Shapefile, available at http://www.census.gov/geo/www/tiger/tgrshp2010/tgrshp2010.html, Table created by Robin Lynch.

[12] U.S. Census Bureau, "2010 TIGER/Line® Shapefiles," November 30, 2010.

[13] U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us; INEGI, 2010 Census, as reported at available at http://www3.inegi.org.mx/sistemas/mexicocifras/default.aspx?e=28.

[14] U.S. Census Bureau, 2010 Census, Center for Health Statistics, Texas Department of State Health Services, available at http://www.dshs.state.tx.us.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Texas Secretary of State, Directory of Colonias Located in Texas, available at http://http://www.sos.state.tx.us/border/colonias/reg-colonias/index.shtml.

[20] INEGI, Censo de Población y Vivienda, 2010; Aguascalientes, Aguascalientes, 2010.

[21] Ibid.

[22] Ibid.

[23] Ibid.

Chapter 2. Water Quality Management Institutions in the Lower Rio Grande

The water quality in the Lower Rio Grande/Río Bravo valley below Falcon Reservoir is an outcome of the shared sovereignty of the river, as the river forms the boundary between Mexico and the United States (U.S.) in the coastal plain adjacent to south Texas and north-west Mexico. The Rio Grande/Río Bravo is a major river ecosystem upon which people and wildlife in Mexico and the U.S. have depended for generations. Users rely on the watershed for irrigation, municipal and industrial water supply, hydroelectric power, industrial water fishing and recreation, wastewater assimilation, and floodwater conveyance. The people and wildlife also release pollutants into the river. Security, population growth, public health, trade, environmental health, poverty, and cultural connections affect the relationship between Mexico and the United States for managing water quality. There are six levels of institutions on both sides of the Mexico/U.S. border interested in water quality: international or bilateral organizations; federal government agencies; state bureaucracies; regional water institutions; local community departments; as well as special purpose water-related districts, private for- profit firms, and not for profit organizations. This chapter describes the institutions involved in joint management of water quality in the Rio Grande/Río Bravo on both sides of the river in the region south and east of Falcon Reservoir, otherwise known as Texas' Rio Grande Segments 2301 and 2302.

Each organization has a stake in both the problem and solution of water quality; they also share constituents and their jurisdictions overlap. At the international level, Mexico and the U.S. created the bilateral International Boundary and Water Commission (IBWC) as the legal authority to work with the agencies of their two federal governments to improve the water quality of the Rio Grande/Río Bravo. Mexico's approach to water quality management begins with the role of its federal agency, the Comisión Nacional de Agua (CONAGUA), which issues permits for both water withdrawal and discharge of wastes in cooperation with state and local institutions. The U.S. water quality regime starts with its key federal agency, the U.S. Environmental Protection Agency (EPA), which delegates authority to issue water discharge permits to a state agency, the Texas Commission on Environmental Quality (TCEQ). Local governments and private organizations, including for-profit businesses or non-profit groups, also have a stake in water quality.

Water Management along the United States Border of Texas

The Clean Water Act (CWA) delegates to EPA responsibility for ambient water quality management of all navigable rivers and lakes, which include the Rio Grande/Río Bravo.[24] The CWA legislation authorizes EPA to delegate primacy to enforce the law to any state that can exercise such authority,[25] and EPA has delegated authority for Texas water quality to the Texas Commission on Environmental Quality (TCEQ).[26] The TCEQ administers Texas' point and non-point water quality permits under EPA supervision. The Texas State Soil and Water Conservation Board (TSSWCB) administer programs for the abatement of agricultural and silvicultural nonpoint source pollution.[27]

The Texas Water Code, the principal water quality law in the state, implements portions of the federal CWA that established a national system for pollutant discharge control.[28] The Texas Clean Water Act (TCWA) requires a biennial water quality assessment, identification and listing of waters not meeting stated criteria, known as annual 303d reports. TCEQ also issues Total Maximum Daily Load (TMDL) reports for waters exceeding pollutant limits.[29] The EPA has delegated the National Pollutant Discharge Elimination System (NPDES) permit program to Texas; any entity that discharges effluent into a water body must obtain a permit.[30] The Texas Water Code applies to groundwater as well as surface water and to nonpoint source as well as point-source pollution.[31]

Any person or entity in Texas is required to obtain a discharge permit to release waste into a water body, including the Rio Grande/Río Bravo.[32] A city with a sewage treatment plant, drinking water treatment plant and storm water sewers would be obliged to obtain at least three different types of TCEQ wastewater discharge permits. An agricultural operation, depending on its size and whether it discharges into state waters, may require permits administered through the TCEQ's Texas Pollutant Discharge Elimination System (TPDES) for concentrated animal feeding or aquatic animal feeding operations.[33] There are no permits required for a farmer whose only discharge is non-point source runoff.

Any industry seeking to discharge into in the lower Rio Grande would file a TPDES wastewater permit through the TCEQ,[34] and after an initial TCEQ review the permit request would be distributed for public comment.[35] Costs for applying for a permit range from $350 to $1,250, with an annual monitoring fee thereafter. If an industry is requesting a permit to discharge into a water body listed on the Texas Clean Water Action Section 303(d), such as parts of the Rio Grande, permission may be denied completely or granted with requirements.[36]

Any entity seeking to withdraw water from the Rio Grande/Río Bravo must obtain a permit through the Rio Grande Watermaster's Office. The lower Rio Grande/Río Bravo below Falcon Dam is unique in Texas because its water is considered a stock resource, rather than a flow, as in the rest of the state.[37] Extraction permits are not based on the usual, state-wide "first in time, first in right" rule, but on a system of adjudicated water rights reflecting the fact that the Rio Grande is an international resource subject to claims of both the Mexico and the U.S based on the 1944 treaty.[38] Each municipal user can ask the Watermaster to release water up to an annual upper limit that is reset every year. Irrigation water withdrawals are allowed up to adjudicated upper limit, with balances carried forward from year to year. Irrigation districts distribute water to agricultural users through the irrigation district in which a farming operation is located. State rules authorize the Rio Grande Watermaster to manage water quality through releases from Amistad and Falcon Dams.[39]

Both Mexico and the U.S. have developed their water rights and wastewater rules based on a series of historical treaties between Mexico and the U.S. These agreements, as well as Mexican and U.S. national legislation, judicial decisions, and administrative rule-making, are discussed below.

Water Management along the Mexico Border of Texas

The Mexican Constitution defines water as a national and strategic commodity.[40] Mexican law delegates to CONAGUA the responsibility to issue permits for withdrawal of waters of the Río Bravo or permission to discharge wastes.[41] CONAGUA's autonomy in the Río Bravo is constrained by international treaties and agreements[42] through the International Boundary and Water Commission (IBWC).[43]

A Mexican farmer, water-user association, irrigation district or city seeking to use water from the Río Bravo must file a permit request to CONAGUA to withdraw water. The individual or irrigation district may apply at the main office of CONAGUA, a regional service center, or online.[44] The applicant must provide information about the site of water withdrawal, the means for water removal, how much will be required on a yearly basis, the water use, and the discharge point of any residual flow.[45] Agricultural users must acknowledge that they are aware of and will discharge water in conformity with Mexican requirements regarding water quality, although they are not required to show proof with their water withdrawal application.[46]

Prior to any permit to withdraw water CONAGUA considers the average annual availability of the water resource.[47] The available volume of water in the Río Bravo is revised at least every three years in cooperation with the IBWC Mexican Section, otherwise known as the Comisión Internacional de Limites y Aguas (CILA).[48] CONAGUA grants permits for water withdrawal for at least 5 and up to 30 years[49] for a fee of $3,077 Mexican pesos, or approximately $240 U.S. dollars (USD), and there is a yearly fee for water withdrawals.[50]

A farmer who belongs to a user association requests water through her or his irrigation district rather than applying directly to CONAGUA for a water concession.[51] CONAGUA requires that any irrigation district adopt appropriate regulations for managing water distribution and administration, protecting the rights of the individual water users, maintaining water infrastructure, charging fees, and discharging wastes. These regulations are not uniform among districts.[52]

A private company that wishes to discharge wastewater after industrial use must apply to CONAGUA for a discharge permit[53] that includes specific information about the type of waste water to be discharged, how and where the discharge will occur, and the approximate volume per day or per year.[54] In addition to taxes paid per volume of discharge, the cost of the permit is $1,405 Mexican pesos, or approximately $110 USD.[55]

Mexican law delegates to CONAGUA the responsibility of determining the necessary parameters for permit-holder discharges to maintain appropriate Río Bravo water quality standards.[56] As part of the wastewater discharge permit application, a private company must submit the results of a water quality analysis carried out by a laboratory accredited by CONAGUA.[57] Any discharge permit-holder must submit further laboratory reports every two years confirming the discharge water quality.[58] Holders of either concession permits or discharge permits must install meters to measure the volume of water being extracted or discharged and submit to CONAGUA meter inspections and other information necessary to remain in conformity with Mexican legislation.[59]

Water Agreements Between Mexico and the United States

Water rights and regulation of discharge rules have been created in the Rio Grande/Río Bravo through a series of bilateral treaties and agreements. The relationship between Mexico and the U.S. could be called "bilateral cooperation through unilateral sovereignty," as each nation separately manages waters within its sovereign territory, subject to its bilateral treaty obligations.

Treaty of Guadalupe Hidalgo (1848)

The Treaty of Peace, Friendship, Limits and Settlement between the United States of America and the Mexican Republic, commonly known as the Treaty of Guadalupe Hidalgo, was the peace treaty that ended the Mexican-American War in 1848. It established the Rio Grande/Río Bravo as the international border between Mexico and the United States.[60] Article XII of the treaty stated that the United States would pay Mexico $15 million "in consideration of the extension acquired by the boundaries of the United States."[61] The treaty does not include any significant provisions regarding water quality.

1906 Rio Grande Treaty

The Convention between the United States and Mexico on Equitable Distribution of the Waters of the Rio Grande, commonly known as the 1906 Rio Grande Treaty, allocated water to "provide for the equitable distribution of the waters of the Rio Grande for irrigation purposes" at the border of New Mexico, Texas, and Mexico.[62] The 1906 treaty also established rules to govern water allocation under "extraordinary drought"[63] and sought to alleviate downstream water shortages by authorizing water diversions and storage works.[64] The treaty does not include any significant provisions regarding water quality.

1944 Rio Grande and Colorado River Treaty

The Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande Treaty, commonly known as the 1944 Rio Grande and Colorado River Treaty, allocated water in tributaries and the main stem of the Rio Grande/ Río Bravo from Fort Quitman to the Gulf of Mexico and created the IBWC/CILA. Article 1 of the 1944 Treaty states that:

> Regulation and exercise of the rights and obligations which the two Governments assume thereunder, and the settlement of all disputes to which its observance and execution may give rise are hereby entrusted to the International Boundary and Water Commission, which shall function in conformity with the powers and limitations set forth in this treaty.[65]

Article 2 establishes that "the jurisdiction of the Commission shall extend to the limitrophe parts of the Rio Grande (Río Bravo)…to the land boundary between the two countries."[66] Article 3 of the Treaty addresses water quality by stipulating that "all of the foregoing uses shall be subject to any sanitary measures or works which may be mutually agreed upon by the two Governments, which hereby agree to give preferential attention to the solution of all border sanitation problems."[67] Minute 261 defined as a "border sanitation problem" any case in which unsanitary waters that present a health hazard or impair the use of the Rio Grande/Río Bravo cross the international boundary. Taken together, these three articles delegate the task of protecting and preserving the water quality of the Lower Rio Grande/Río Bravo to the IBWC.[68]

Rio Grande Compact of 1938

The Rio Grande Compact of 1938 sought to resolve water-use conflicts among the U.S. states of Texas, New Mexico, and Colorado through the "equitable apportionment of such waters," downstream from Colorado to New Mexico and from New Mexico to Texas.[69] The compact does not include any significant provisions regarding water quality.

Pecos River Compact of 1948

The Pecos River Compact created rules to govern the volume and quality of water downstream in the Pecos River, a tributary of the Rio Grande,[70] and "facilitate the construction of works for: the salvage of water, the more efficient use of water, and the protection of life and property from floods."[71] The compact does not include any significant provisions regarding water quality.

La Paz Agreement of 1983

Presidents Reagan (U.S.) and de la Madrid (Mexico) signed the Agreement between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area, commonly known as the La Paz Agreement of 1983. The La Paz Agreement authorized each nation's environmental agency to coordinate together environmental improvements along their international boundary and authorized a joint report on binational environmental programs, which later evolved into Border 2012 and Border 2020, a collaboration aimed at improving the health of citizens living along both sides of the border.[72]

Article 1 of the La Paz Agreement declares that "the United States of America and the United Mexican States…agree to cooperate in the field of environmental protection in the border area."[73] Article 2 adds that the two countries will "adopt the appropriate measures to prevent, reduce and eliminate sources of pollution in their respective territory which affect the border area of the other."[74] In order to monitor the effectiveness of their work, Article 10 requires the United States and Mexico to "hold at a minimum an annual high level meeting to review the manner in which this Agreement is being implemented."[75] Article 12 requires that "the national coordinators of both Parties will present to the annual meetings a report on the environmental aspects of all joint work conducted under this Agreement."[76] Annex II of the La Paz Agreement establishes the "Joint Contingency

Plan" and names the USEPA and the Secretario de Desarrollo Urbano y Ecologia of Mexico (now known as the Secretario de Desarrollo Social) as the "coordinating authorities" for the Plan:

> The Parties agree to establish the 'United States-Mexico Joint Contingency Plan'…The object of the Plan is to provide cooperative measures to deal effectively with polluting incidents…The coordinating authority for the Plan for the United States of America is the Environmental Protection Agency. The coordinating authority for the Plan for the United Mexican States is the Secretaria de Desarrollo Urbano y Ecologia.[77]

Furthermore, Annex II of the La Paz Agreement makes clear that "nothing in this Agreement shall prejudice or otherwise affect the functions entrusted to the International Boundary and Water Commission, in accordance with the Water Treaty of 1944."[78]

North American Free Trade Agreement of 1993

The North American Free Trade Agreement (NAFTA), signed by the United States, Canada and Mexico in 1993,[79] "created the world's largest free trade area, which now links 450 million people producing $17 trillion worth of goods and services."[80] The NAFTA treaty included two environmental side agreements creating three organizations: the North American Commission for Environmental Cooperation (NACEC) the Border Environmental Cooperation Commission (BECC), and North American Development Bank (NADB). The NACEC side agreement seeks to "broaden environmental cooperation among the parties" and provide "a forum for the parties to consider ways to address environmental issues" and "an avenue for dispute settlement panels to obtain environmental expertise."[81] The BECC/NADB side agreement established the two bilateral organizations to "help border communities finance environmental infrastructure projects."[82] Further discussion of these institutions and their respective roles in water quality management is discussed below.

Bi-National Institutions

Through their bi-national treaties Mexico and the United states have created three bi-lateral and one tri-lateral organizations to assist in managing the border environments. These organizations are discussed below.

International Boundary and Water Commission and La Comision Internaccional de Limites y Aguas

The Treaty of 1944 created the International Boundary Water Commission (IBWC) / La Comisión Internacional de Limites y Aguas (CILA) located in El Paso Texas (IBWC) and Ciudad Juarez, Chihuahua, Mexico (CILA) respectively. Hereafter, the term IBWC will refer to the IBWC/U.S. section which "operates under the foreign policy guidance of the Department of State."[83] The term CILA will be used for the IBWC/Mexican section. The IBWC's mission is "to provide bi-national solutions to issues that arise during the application of United States-Mexico treaties regarding boundary demarcation, national ownership of waters, sanitation, water quality, and flood control in the border region,"[84] including the "solution of border sanitation and other border water quality problems."[85] Table 2.1 lists key IBWC/CILA activities related to regional water quality.[86]

Table 2.1 IBWC/CILA Activities Related to Rio Grande/Río Bravo Water Quality

• Flood control levee systems of the Rio Grande/Río Bravo
• Safety and emergency management of dams, diversion of dams, power plants, wastewater treatment plants
• Texas Clean Rivers program
• Water delivery to Mexico and the U.S. as approved by the 1944 Water Treaty
• Flood control in the Upper Rio Grande, Presidio, Texas-Ojinaga, Chihuahua, and Lower Rio Grande regions
• Amistad, Falcon, Anzalduas, and Retamal Dam maintenance and operation
• Construction of weirs in Laredo, Texas-Nuevo Laredo, Tamaulipas, Brownsville, and Texas-Matamoros
• Water conservation in Mexican and U.S. irrigation districts
• Invasive species projects
• Presidio, Texas - Ojinaga, Chihuahua, Laredo, Texas - Nuevo Laredo, and Tamaulipas sanitation projects
• Rio Grande floodplain projects
• Regular water quality monitoring
• Creation and maintenance of a geographic information system and a bi-national water quality database

Source: International Boundary and Water Commission, "2008 Annual Report," last modified 2008, accessed April 8, 2012, available at http://www.ibwc.state.gov/Files/2008_report_English.pdf.

Border Environment Cooperation Commission/Comisión de Cooperación Ecológica Fronteriza and the North American Development Bank

An environmental side agreement of the North American Free Trade Agreement of 1993 (NAFTA), the North American Agreement on Environmental Cooperation, created the Border Environmental Cooperation Commission (BECC) and the North American Development Bank (NADB) to preserve and promote the health and welfare of border residents and their environment.[87] The BECC, located in Ciudad Juarez, Chihuahua, and the NADB, located in San Antonio, Texas, constitute an innovative, bi-national approach to environmental infrastructure development and financing in the U.S.-Mexico border region.[88] NADB and BECC can authorize grants to communities in the "Border Region," defined as 100 kilometers north of the U.S.-Mexico boundary and 300 kilometers south, within Arizona, California, New Mexico, Texas, Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas.[89] In 2004, Mexico and the U.S. reorganized the parallel BECC and NADB boards into a single board of Mexican and American representatives to manage the BECC and NADB.[90] Table 2.2 lists BECC and NADB responsibilities.[91]

Table 2.2 BECC and NADB Responsibilities

BECC	NADB
• Certifies the technical feasibility and environmental - health impacts of project • Ensures transparency and promote community-based support for project • Provides technical assistance for project development • Funds projects via the Project Development Assistance Program (PDAP)	• Provides financing for project implementation • Offers guidance on financial issues • Provides technical assistance for project development and institutional strengthening • Provides funds through loans and the Border Environment Infrastructure Fund (BEIF)

Source: Border Environmental Cooperation Commission, "BECC and NADB Successful Binational Cooperation," accessed April 10, 2012, available at http://www.becc.org/english/index.html.

The BECC/NADB mission is to "serve as a bi-national partner and catalyst in communities along the U.S.-Mexico border in order to enhance the affordability, financing, long-term development and effective operation of infrastructure that promotes a clean, healthy environment for the citizens of the region."[92] BECC has evaluated and NADB has financed projects through grants and loans, as listed in Table 2.3,[93] that support a diversity of water infrastructure projects, including drinking water supply, water treatment and distribution, wastewater collection, treatment and reuse, water conservation, as well as storm drainage and flood control (see Table 2.4).[94] Special financial amounts for NADB and BECC are listed in Tables 2.5 and 2.6. NADB administers infrastructure construction programs through the Border Environment Infrastructure Fund (BEIF)[95] to "prevent, control or reduce environmental pollutants or contaminants, improve the drinking water supply, or protect flora and fauna, so as to improve human health, promote sustainable development, or contribute to a higher quality of life."[96]

Table 2.3 BECC and NADB Water Quality Funding Programs

Fund	Purpose
Border Environment Cooperation Commission (BECC)	
Project Development Assistance Program (PDAP)	Supports the development of projects related to drinking water and wastewater infrastructure.
Technical Assistance (TA) with BECC Funds	Aids BECC project sponsors with human resource development planning and operations assistance for water, wastewater, solid waste, and new sector projects.
Special Grants	Border initiatives aimed at improving human health and the environment.
Border 2012 Program	BECC provides management support for project implementation and logistical support for stakeholders.
North American Development Bank (NADB)	
Loan Program	Provides direct financing from NADB in the form of loans or guaranties for construction of BECC-certified environmental projects. Projects sponsored by public entities in Mexico receive financing through COFIDAN.
Border Environment Infrastructure Fund (BEIF)	Grant resources provided by EPA's U.S.-Mexico Border Program for water and wastewater infrastructure projects.
Solid Waste Environmental Program (SWEP)	SWEP financed municipal solid waste projects from 1999 to February 2011. NADB has discontinued the program.
Water Conservation Investment Fund (WCIF)	Grant financing for water conservation projects in the border region by allocating US$80 million of NADB's retained earnings, US$40 million for each country.
Community Assistance Program (CAP)	Program created in February 2011 and accepting proposals for the first time in 2012. Grants are available for public projects in all sectors, with priority given to drinking water, wastewater, and solid waste infrastructure.
Technical Assistance Program (TAP)	Funding for studies related to design and implementation of environmental infrastructure projects.
Utility Management Institute (UMI)	Training/education program for managers of water utilities, with focus on financial administration.

Source: BECC and North American Development Bank (NADB), "Joint Status Report, September 30, 2011," 14-18, "Joint Status Report: Quarterly Status Report, December 31, 2011," available at http://www.nadb.org/pdfs/FreqUpdates/JointStatusReport.pdf; BECC and NADB.

Table 2.4 BECC Project Certifications

Projects	Total	U.S.	Mexico
Water and wastewater	113	52	61
Water conservation	25	24	1
Storm Water	2	1	1
Solid Waste	22	5	17
Air Quality	20	0	20
Clean Energy	5	4	1
Basic Urban Infrastructure	2	0	2
Total	189	86	103

Source: BECC and NADB, "Quarterly Status Report, December 31, 2011," 15.

Table 2.5 Total NADB Project Financed Support (in US $ millions)

	Total	U.S.	Mexico
Projects with NADB financing	152	73	79
Total project costs	$3,280.4	$1,143.0	$2,137.4
Total contracted	$1,325.8	$518.4	$807.4
Loans	$667.4	$188.9	$478.5
BEIF	$568.7	$287.0	$281.7
SWEP	$9.8	$2.5	$7.3
WCIF	$79.9	$39.9	$40.0
Total disbursed	$1228.1	$473.8	$754.3

Source: BECC and NADB, "Quarterly Status Report, December 31, 2011," 19.

Table 2.6 BECC Expenditures

Country	Unique Communities Supported	Projects	Amount (US$)	Percentage
Mexico	72	188	$15,143,129	37%
USA	90	146	$25,330,996	63%

Total	162	334	$40,474,125	100%

Sources: BECC and NADB, "Quarterly Status Report, December 31, 2011," 16.

Both Mexican and the U.S. governments take pride in the positive impact of BECC and NADB on Rio Grande/Río Bravo water quality, although both governments have acknowledged that there remains more work to be done. Daniel Chacón Anaya, former BECC General Manager, noted in 2010 that 82 percent of the wastewater on the Mexican side is now being treated, compared to 42 percent for the rest of the country. "The big difference between these two figures is precisely the result of this joint effort between the two countries to eliminate the backlog of unmet needs that has for many years existed along the border," according to Mr. Chacón. He noted that BECC has received increasing numbers of applications each year and that "this demonstrates the willpower to work together, providing the necessary funding, but above all providing the willpower to coordinate with each other."[97] Mr. Chacón acknowledged that "this tells us that there is still a great deal of unmet needs requiring investments. We estimate that Mexico needs to invest more than $700 million dollars in order to achieve 100 percent coverage. Probably by the year 2015 or 2016, we will be able to claim victory for having achieved coverage close to 100 percent on both sides on the border and we'll be able to say that we have a clean border, especially with respect to the river."[98]

The U.S.-based Good Neighbor Environmental Board noted in 2010 that wastewater treatment has improved in the Rio Grande/Río Bravo since 1995 due to projects certified by the BECC (as financed by the EPA via BEIF of NADB), as well as through other investments by federal and state agencies on both sides of the border.[99] Despite the bilateral progress, funding continues to be a limitation, as requests outpace available funds. For example, in fiscal year (FY) 2010 BECC received more than $1.1 billion in project funding requests, more than 65 times the amount budgeted.[100] As of September, 30, 2011, an additional 51 projects were in the project development pipeline, with an estimated US $1.35 billion as yet unfunded.[101]

North American Commission on Environmental Cooperation (NACEC)

The North American Commission on Environmental Cooperation (NACEC) was created through a NAFTA side agreement[102] "to broaden environmental cooperation" and to provide "a forum…to consider ways to address environmental issues" and "an avenue for dispute settlement panels to obtain environmental expertise" between the United States, Mexico and Canada.[103] The Commission is located in Montreal and includes a Council, a Secretariat and a Joint Public Advisory Committee.[104] "The Council is the governing body of the Commission and comprises cabinet-level or equivalent representatives of each country. The Secretariat provides technical, administrative and operational support to the Council. The Joint Public Advisory Committee (JPAC) - five citizens from each country - advises Council on any matter within the scope of the [North American Agreement on Environmental Cooperation]."[105]

Water Institutions of the United States

Mexico and the United States retain sovereign authority to manage water quality within their respective nations even though they have created international institutions (IBWC/CILA, BECC/NADB, NACEC) to facilitate bi-lateral environmental cooperation along the border. This section describes the U.S. national institutions.

U.S. Environmental Protection Agency (EPA)

The official mission of the EPA is to "protect human health and the environment,"[106] and water quality management is one component of this mission. The EPA "enforces federal clean water and safe drinking water laws, provides support for municipal wastewater treatment plants, and takes part in pollution prevention efforts aimed at protecting watersheds and sources of drinking water."[107] The Clean Water Act (CWA) "establishes the basic structure for regulating discharges of pollutants [from point sources] into the waters of the United States and regulating quality standards for surface waters."[108] Under the CWA, anyone who wants to discharge pollutants into surface water must first obtain a National Pollutant Discharge Elimination System (NPDES) Permit.[109] The CWA authorizes the EPA to delegate the NPDES to state governments, enabling states to administer and enforce aspects of the NPDES program under EPA oversight.[110] The EPA has delegated authority to the TCEQ to administer the NPDES program in Texas.[111] The ambient water quality in some sections of the Rio Grande/Río Bravo does not meet CWA standards.

The Safe Drinking Water Act (SDWA) authorized the EPA to protect drinking water quality, or "all waters actually or potentially designed for drinking use, whether from above ground or underground sources."[112] Under the SDWA, the EPA sets minimum standards for water distributed to the public as drinking water and requires the EPA to establish minimum standards for state programs to protect surface or underground sources of drinking water from hazards such as underground injection of fluids.[113]

The diversity of treaties and laws create some uncertainty as to which agency is "responsible" for the Rio Grande/Río Bravo water quality. The 1944 treaty designates the IBWC as responsible for sanitation and other border water quality problems.[114] The CWA authorizes the EPA to enforce water quality standards on navigable rivers, such as the Rio Grande. The EPA has delegated to Texas the responsibility for water quality management through the NPDES program. Each of the three levels of government (the IBWC, EPA and TCEQ) have a role in assurance of ambient water quality, as the Rio Grande/Río Bravo is at once a river of Texas, within the U.S. and simultaneously is the border between the U.S. and Mexico.

Border 2020 (previously called Border 2012) is a bi-national environmental program co-administered by the EPA with its Mexican counterpart, SEMARNAT to implement the La Paz Agreement. It "focuses on cleaning the air, providing safe drinking water, reducing the risk of exposure to hazardous waste, and ensuring emergency preparedness along the U.S.-Mexico border."[115] Border 2020 provides technical and financial assistance through the BECC's Project Development Assistance Program (PDAP) and facilitates project financing and construction via the NADB its Border Environment Infrastructure Fund (BEIF),[116] supported by EPA. The annual BEIF contributions have varied as Congress' annual appropriation has dwindled since BEIF's inception; it is uncertain what level of grant funds will be available in the future. The La Paz Agreement reinforced the IBWC's responsibilities for sanitation in border rivers: "Nothing in the Agreement shall prejudice or otherwise affect the functions entrusted to the International Agency of Water Commissions in accordance with the Water Treaty of 1944."[117]

United States Geological Survey (USGS)

The United States Geological Survey (USGS) serves "the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life." [118] The USGS collects, analyzes, and interprets water-quality and quantity data[119] for surface water, ground water, and water use.[120] The USGS works through various local, state, and federal agencies to identify and understand environmental issues and concerns and it disseminates information to improve water resource planning and management use-planning.[121]

Texas Commission on Environmental Quality (TCEQ)

The Texas Commission of Environmental Quality's (TCEQ) mission is to "protect… [Texas'] human and natural resources consistent with sustainable economic development,"[122] through clean air, clean water, and the safe management of waste.[123] A TCEQ water master oversees water allocation in the Rio Grande region and is responsible for "coordinat[ing] releases from the Amistad and Falcon reservoir system for irrigation, municipal and industrial uses."[124] TCEQ issues water rights permits and regulates effluent discharge into surface water to satisfy the requirements of the federal Clean Water Act and Texas' Surface Water Quality Standards.[125] To comply with federal CWA regulations, the TCEQ produces a "Texas Integrated Report" every two years that identifies water bodies that are not meeting ambient quality standards, otherwise known as Texas' 303(d) list,[126] which is subject to review and approval. The TCEQ administers various types of discharge permits. For instance, "domestic facilities that dispose of treated effluent by discharge into waters in the state are required to obtain a Texas Pollutant Discharge Elimination System (TPDES) permit."[127] Any facility that disposes of treated effluent by land application (surface irrigation, evaporation, drain fields or subsurface land application) must obtain a Texas Land Application Permit (TLAP) permit.[128]

Within the Lower Rio Grande Basin, the Rio Grande Watermaster administers the water allocation process and releases water from the Amsted and Falcon reservoirs for irrigation, municipal, industrial and other water uses. The TCEQ's also conducts environmental reviews as part of any of water right permit application. TCEQ staff evaluate available information related to a proposed water project to consider potential impacts to fish and wildlife habitat, water quality, in stream uses associated with the affected body of water and downstream areas, and if the project is within 200 river miles from the Texas coast, freshwater inflows to bays and estuaries are also addressed."[129]

Applicants are asked to provide a Supplemental Environmental Information Sheet along with their water right permit application.

TCEQ publishes quarterly a border initiative action plan that addresses air, water, and other environmental concerns,[130] as part of the EPA's Border 2020 program. One component of the TCEQ's plan is to develop a lower Rio Grande Pilot Water Quality Initiative. "The TCEQ will work with local, state, and federal agencies from both the U.S. and Mexico to collect data and develop a framework for a Watershed Action Plan to address indicator bacteria in the TCEQ's Rio Grande Segment 2302, the 231-mile-long reach of the Rio Grande below Falcon Reservoir."[131] For example, U.S and Mexican agencies may cooperate to collect water samples from the Rio Grande and analyze the pollutant sources.[132] The Texas Commission on Environmental Quality (TCEQ) regulates public water systems in Texas, or any "system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals."[133]

The TCEQ is the Texas entity responsible for enforcing water quality regulations, regulating public water systems, and regulating the operation of surface water treatment plants.[134] The TCEQ provides technical and logistical assistance for maintaining water quality standards throughout the state to include municipal water systems.[135] The TCEQ provides "measures that ensure that water produced and distributed by a public water system is safe to drink."[136] The agency provides public water systems and interested citizens with "consumer confidence reports, monitoring requirements, notification requirements, and other reporting requirements."[137]

Texas Water Development Board (TWDB)

The Texas Legislature created the Texas Department of Water Resources (now the Texas Water Development Board or TWDB) in 1957 by legislative act and constitutional amendment. Texas voters later approved issuance of $200 million in State of Texas General Obligation Water Development Bonds "for the conservation and development of Texas' water resources through loans to political subdivisions."[138] In 1985, the Texas Legislature "split the agency into a Texas Water Commission, the TCEQ that regulates water quality, while the Texas Water Development Board is responsible for long-range planning and water project financing."[139] Table 2.5 lists TWDB responsibilities.[140]

Table 2.7 Texas Water Development Board Responsibilities

Grant Programs
• The Texas Water Development Board (TWDB) provides loans and grants to local governments for water supply projects, water quality projects including wastewater treatment, municipal solid waste management and nonpoint source pollution control, flood control projects, agricultural water conservation projects, and groundwater district creation expenses.

- The TWDB authorizes grants and loans for the water and wastewater needs of the state's economically distressed areas.
- The TWDB makes available agricultural water conservation funding and water-related research and planning grants.

Information and Planning Programs

- The TWDB supports regional water plans that are incorporated into a statewide water plan for the orderly development, management, and conservation of the state's water resources.
- The TWDB studies Texas' surface and groundwater resources.
- The TWDB collects data and conducts studies concerning the fresh-water needs of the Texas' bays and estuaries.
- The TWDB administers the Texas Water Bank, which facilitates the transfer, sale or lease of water and water rights throughout the state, and administers the Texas Water Trust, where water rights are held for environmental flow maintenance purposes.
- The TWDB maintains a centralized data bank of information on the state's natural resources called the Texas Natural Resources Information System and manages the Strategic Mapping Program, a Texas-based, public and private sector cost-sharing program to develop consistent, large-scale computerized base maps describing basic geographic features of Texas.

Source: Texas Water Development Board (TWDB), "About Texas Water Development Board," accessed April 10, 2012, available at http://www.twdb.state.tx.us/about.

The TWDB's mission is "to provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas."[141] "To accomplish its goals of planning for the state's water resources and for providing affordable water and wastewater services, the TWDB provides water planning, data collection and dissemination, financial assistance and technical assistance services to the citizens of Texas."[142] Of special interest in the Rio Grande Basin is the TWDB's Economically Distressed Areas Program (EDAP), established by the 71st Texas Legislature in 1989 to provide grants and loans for water and wastewater services in economically distressed areas that have facilities "inadequate to meet residents' needs."[143] The TWDB "financial assistance programs are funded through state-backed bonds, a combination of state bond proceeds and federal grant funds, or limited appropriated funds. Since 1957, the Legislature and voters approved constitutional amendments authorizing the TWDB to issue up to $2.68 billion in Texas Water Development Bonds. To date, the TWDB has sold nearly $1.55 billion of these bonds to finance the construction of water- and wastewater-related projects."[144] The TWBD works with the Texas Commission on Environmental Quality to facilitate water permitting purposes.[145]

Rio Grande Regional Water Authority

Senate Bill 1902 created the Rio Grande Regional Water Authority (RGRWA) in 2003, replacing the former Lower Rio Grande Authority.[146] The RGRWA serves six counties in South Texas: Willacy, Cameron, Hidalgo, Starr, Zapata, and all parts of Webb County not encompassed by the city of Laredo.[147] The Authority is a conservation and reclamation district responsible for water treatment, wastewater treatment, conveyance, and desalination.[148] The RGRWA does not replace existing authorities or services provided by municipalities, counties, irrigation districts, or water development supply corporations. Instead, the RGRWA assists other entities with their existing water management duties and functions. It is funded through a variety of bonds, grants, loans, and other available sources.[149] The RGRWA is led by an 18-member Board of Directors comprised of gubernatorial and county appointees.[150] Members of irrigation districts, water supply corporations, and the general public serve on the Board.[151] As all six counties must be represented (a maximum of three members may come from a single county), the Authority ensures a diversity of opinions and interests will inform its decision-making process. Committees have been created to address community outreach, finance, legislation, groundwater management, and drainage.[152]

U.S. Irrigation Districts

An irrigation district is "a cooperative, self-governing public corporation set up as a subdivision of the state government, with definite geographic boundaries, organized, and having taxing power to obtain and distribute water for irrigation of lands within the district."[153] Under Texas state law, "Irrigation districts…are limited purpose districts established primarily to deliver untreated water for irrigation and to provide for the drainage of lands and such other functions as are incidental to the accomplishment of such limited purposes. An irrigation district shall not engage in the treatment or delivery of treated water for domestic consumption or the construction, maintenance, or operation of sewage facilities or provide any other similar municipal services."[154]

In the Lower Rio Grande Valley there are 29 irrigation districts, with a total service area of 759,481 acres operating through a canal system 3,174 miles long.[155] Irrigation districts "provide an adequate, reliable source of water for irrigation, municipal, industrial and domestic uses and afford drainage insofar as reasonably possible to the lands located within District boundaries."[156] Texas state law allows irrigation districts in the Lower Rio Grande Valley to take water from the Rio Grande River, and "this water is transported from the Rio Grande River via canals."[157] The Brownsville Irrigation district is the only one to transport water underground with pipelines instead of by canal.[158] The watermaster in the Rio Grande oversees the distribution of water in the Rio Grande Valley, and the watermaster must grant approval before water can be taken out of the Rio Grande.[159]

Two classes of water rights permits exist in the Rio Grande Valley, A and B.[160] This system was created in response to a severe drought in the 1950s when "claimed water rights exceeded available supply."[161] Water rights in the Rio Grande Valley were divided into Classes A and B; those who could prove they had a water right during the drought were given a Class A permit, and these superseded Class B permits, which were awarded to those with less certain claims.[162] This classification of water rights becomes central in years with little rainfall, as the water rights permit system "distribute[s] the shortage among all users, with greater shortages occurring on lands with Class B water rights."[163] Today, municipal rights take precedence over irrigation rights, and "[w]hen Class A irrigation water rights are changed from agricultural use to municipal or industrial use, the amount of water associated with those rights is cut by 50 percent. Class B water rights would be reduced to 40 percent of the original allocation in the same situation."[164]

The irrigation districts control most of the U.S. water in the lower Rio Grande. "Of all the 1.9 million acre-feet of irrigation rights in the Valley, 85 percent (or 1.6 million acre-feet) are held by irrigation districts. Another 13 percent (250,173 acre-feet) are in private hands, with the remainder held by federal, state, or municipal governments."[165] Table 2.8 compares differences between water rights in the lower and middle Rio Grande versus to the rest of Texas.[166]

Table 2.8 How Texas Water Law Differs in the Rio Grande

Lower and Middle Rio Grande	The Rest of Texas
Water is a stock resource.	Water is a flow resource.
No time priority.	First in time is first in right.
Burden of water shortages is carried by all irrigators proportionally; municipal water always begin each year at 100 percent of face value.	During shortage, senior water right holders get 100 percent of their entitlement, regardless of use; if there is insufficient water for all users, while junior rights are denied.
Municipal water rights are separate from and superior to irrigation rights.	Senior irrigation rights are superior to junior municipal rights.
All diversions from the Rio Grande must have the watermaster's prior approval.	No prior approval is needed; reporting is required at the end of the year.

Source: David Joseph Hurlbut, "Irrigation for Sale: A Case Study of Water Marketing and Conservation in the Rio Grande Valley of Texas," PhD dissertation, The University of Texas at Austin, 1999, 137, accessed April 8, 2012, available at http://www.cypressrose.com/david/watermarkets.pdf.

Local Municipalities

Municipalities serve as local governing entities that provide city and town citizens with public health, public water systems, waste water collection and treatment, drainage control, and other services. Municipal public health departments provide citizens with information on wellness, vector control, health and food inspections, health alerts, and health ordinance enforcement.[167] Although municipal public health departments do not directly regulate water quality, municipal public health departments are concerned with water quality in regards to water and food borne illnesses. Public water systems in the Lower Rio Grande Valley deliver irrigation services, public drinking water, information on water restrictions, raw water and wastewater treatment, and other services.[168] The Lower Rio Grande Valley municipalities receive water primarily from the Rio Grande through a variety of agreements and treaties.

Nature Preserves

There are two major nature reserves above Texas' southeastern boarder, the World Birding Center and the Nature Conservancy's Southmost Preserve. The World Birding Center, a network of nine sites along the 120 miles of river road from South Padre Island to Roma, works with the U.S. Fish & Wildlife Service, Texas Parks and Wildlife Department and nine valley communities to protect birds and advocate for wildlife conservation.[169] Their mission is, "To significantly increase appreciation, understanding and active conservation of the habitat, birds and other wildlife for current and future generations through education, community involvement, and sustainable nature tourism." The World Birding Centers see the effects of water quality changes through the health of the birds and other wildlife that inhabit the Lower Rio Grande.[170]

The Southmost Preserve is located on a bend of the Rio Grande at the southernmost part of Texas. It is a part of the Boscaje de la Palma region of the Lower Rio Grande Valley Wildlife Corridor. The 1,034 acre property houses one of the last patches of native sabal palm trees in the country. The Preserve's rich biological diversity has attracted the attention of conservation biologists for many years. This area is sometimes referred to as the "Jewel of the Rio Grande Valley" due to its ecological importance parts in the region.[171] The Preserve promotes community-based conservation and outreach, conducts ecological research, restores native brush and resaca, and removes exotic species. The Nature Conservancy works to protect the habitat at this site and conducts research on the compatibility of agricultural activities with nature conservation.[172]

Mexican Institutions

Mexico has a federal government system under which national institutions initiate most water quality investments. Below is a discussion of key Mexican federal, state, and local institutions.

CONAGUA

Mexico created through its 1989 National Water Law the National Water Agency, Comisión Nacional del Agua (CONAGUA), as the federal water authority to "manage and preserve the national waters and their inherent goods in order to achieve sustainable use, with joint responsibility of the three tiers of government (federal, state and municipal) and society as a whole."[173] Since 1994 when CONAGUA was transferred out of the agricultural ministry and into SEMARNAP the agency shifted its focus "away from agricultural productivity and towards environmental sustainability."[174] However, CONAGUA functions independently of SEMARNAT as its operating budget has historically been approximately ten times as large as all of SEMARNAT and its related agencies.[175] CONAGUA drafted and implements most of the National Water Plan (2007-2012) and the 2030 National Water Agenda (adopted in 2011).[176] CONAGUA also helps municipalities improve, repair, maintain, and expand water and wastewater infrastructure. Many of its programming goals for 2007-2012 are related to increasing wastewater coverage in urban and rural areas and ensuring the availability of potable water for consumption.[177]

CONAGUA was reorganized as a result of reforms to the National Water Law in 2004 to decentralize water management activities.[178] River basin councils (*consejos de cuenca*) were established to correspond with thirteen "hydrological-administrative" regions, including the Río Bravo.[179] The headquarters for the Río Bravo's river basin council is in Monterrey, Nuevo Leon.[180] Although the reforms to the National Water Law officially passed in 2004, the river basin councils were not formally established until November 2006, nor fully defined territorially until December 2007.[181] As water is defined within the Mexican Constitution as a public good with ownership at the national level, efforts to decentralize have faced significant institutional resistance.[182]

The CONAGUA federal office still exercises budgeting authority for the entire agency, as well as direct authority over projects, programs, studies, hydraulic infrastructure projects and other rural and urban hydraulic services in waters that are governed bi-nationally.[183] CONAGUA at the federal level also retained direct authority over the regulation, control and preservation of water quality and quantity in border regions.[184] While the regional river basin councils are charged with implementing many of the day-to-day administrative tasks related to permitting, the federal office retains de facto authority.[185]

CONAGUA grants and monitors concessions and permits for water use and discharge, collects tariffs and taxes associated with water rights and usage, and distributes federal funds for infrastructure, potable water, and wastewater treatment projects. Between 2008 and 2010, the general revenue collected by CONAGUA increased from 10,299 million pesos (727 million USD) to 11,039 (780 million USD). In 2010, CONAGUA distributed 1,881 million pesos (132 million USD) to potable water infrastructure, sewer systems, and municipal wastewater treatment facilities, including just over 20 million pesos (1.4 million USD) to the state of Tamaulipas and 134 million pesos (9.4 million USD) to Nuevo Leon.

The current National Water Law allows for the creation of Water Banks (*bancos de agua*) meant to improve "the regulation of the market for water rights, contributing to the efficient use of this resource and move away from its overexploitation."[186] Water Banks are essentially clearinghouses for information related to water rights. They "offer assessments in the administrative process of acquiring water rights and feasibility studies," as well as provide "information about the supply and demand for water" within their respective jurisdiction.[187] The first Water Bank was created in 2008, though the regulations governing their operations have yet to be codified as of 2012.[188] Due to water scarcity and overuse in the northern and central regions of Mexico, Water Banks can facilitate the transfer of water rights and avoid the "informal" and "clandestine" nature of previous transactions, as it is no longer feasible to grant new concessions.[189] The Water

Bank for the Río Bravo was established in September 2009 and is operated out of the regional river basin council.[190]

SEMARNAT

The Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), the Ministry of Environment and Natural Resources, is Mexico's national environmental ministry. Authorized under the Mexican federal Public Administration Law of 2000, SEMARNAT's stated mission is to "promote the protection, restoration and conservation of ecosystems, national resources and environmental goods and services in Mexico, with the objective of creating favorable conditions for their use and sustainable development."[191] SEMARNAT incorporates an environmental perspective into the National Development Plan (2007-2012) through the federal Environment and Natural Resources Plan (2007-2012).[192] SEMARNAT coordinates the Environmental Program for the Northern Border, which includes the strategic use of border natural resources and improved bi-national coordination.[193] SEMARNAT oversees the work of Mexico's National Water Commission, CONAGUA and shares authority over Mexico's federal water quality standards.

IMTA

The Instituto Mexicano de Tecnología del Agua (IMTA), the Mexican Institute for Water Technology, is coordinated through SEMARNAT under the jurisdiction of the federal Public Administration Law. IMTA works to "produce, introduce and disseminate knowledge, technology and innovation for the sustainable management of water in Mexico."[194] IMTA was created in 1986 and serves as the principal technical advisor to CONAGUA, with some of its mandate coming directly from the National Water Law.[195] It is involved in scientific investigation; development, adaptation and transfer of technology; innovation in water resource management; training experts; and serving as a consultant for specialized technical and scientific projects.[196] Some of its program areas include irrigation and drainage, water treatment and water quality, hydraulics and hydrology.[197] As part of the 2007-2012 National Water Plan, IMTA has carried out a project to evaluate water utilities providers and how to improve services and conserve water; it has evaluated 13 water utilities providers in Tamaulipas.[198]

SEDUMA

Within the Mexican state of Tamaulipas, the SEDUMA (Secretario de Desarrollo Urbano y Medio Ambiente) is the state ministry of urban development and the environment. SEDUMA seeks to ensure the balanced and sustainable utilization of water resources, preserving water in quantity and quality, while also aiming to contribute to the economic and social development of Tamaulipas.[199] The agency also ensures the opportunity to strengthen technical and administrative support to the state's water utilities, and seeks to reverse the water availability deficit by promoting efficient use throughout the region.[200] SEDUMA collaborates with the Texas state environmental agency TCEQ on border environmental issues. SEDUMA oversees Comisión Estatal del Agua de Tamaulipas, Tamaulipas' State Water Commission of Tamaulipas (CEAT).

CEAT

Tamaulipas' Water Law of 2006 created the State Water Commission of Tamaulipas (CEAT)[201] to "attend to water concerns of quantity and quality, sanitation and re-use in Tamaulipas" and "promote the rational and efficient use, as well as just and equitable distribution to all sectors of water users with the goal of bringing about sustainable development."[202] CEAT has created program proposals to expand or improve water-related infrastructure; coordinated the maintenance and conservation of water-related infrastructure used by the municipal utilities providers; implemented feasibility studies for how municipal utilities provide water services, including the determination of fees; provided technical assistance and training to irrigation districts and utilities providers; and conducted water quality inspection and verification visits that include taking samples and providing analysis of water quality.[203] CEAT is accountable to the Secretaries of Finance and Administration of the State of Tamaulipas.[204]

COMAPAs and JADs

Since the water decentralization reforms in Mexico, municipalities have been charged since 1999 with public services including "drinking water and wastewater collection, treatment and disposal."[205] Municipalities are bound by "federal regulations, state legislation, and local statutes," but have some freedom as to how to organize the provision of utilities.[206] Two complimentary water organizations exist in Tamaulipas, Municipal Councils for Potable Water and Sewer Systems (COMAPAs) and Water and Waste-Water Boards (JADs).[207] While COMAPAs are by definition more decentralized, there is "no significant difference in the way they are administered since both have a manager and are governed by administrative councils."[208] Matamoros is currently the only municipality in Tamaulipas opting for a JAD[209] to operate into water, drainage, and waste-water systems. The JAD seeks to fulfill this goal through the implementation of short, medium, and long term plans for the expansion and improvement of services.[210]

Municipal utility providers may be quasi-independent institutions, but they must receive formal water allocations from CONAGUA.[211] Allocations to utility providers differ from concessions to private individuals or companies, as utility providers cannot sell or transfer title to the water,[212] so "local water service providers are faced with the challenge of privatizing the resource within a legal and social context that recognizes access to water as a basic civil right," rather than a private commodity.[213] When federal funding provided to municipal utility providers was reduced as a result of the decentralization of the 1990s, infrastructure and waste-water systems suffered as utility service providers had difficulty increasing their income in order to make up the difference.[214] Utility providers have difficulties in collecting fees and an unclear legal mandate for the disconnection of service due to the conception of water as a basic right of the population rather than a private commodity.[215] Instead of increasing fees associated with water usage, utility providers have instead opted to promote a "culture of water" that emphasizes conservation.[216]

Mexican Irrigation Districts

Mexican irrigation often is managed through irrigation districts that are constituted by executive decree within defined geographical areas.[217] Districts may be divided into smaller irrigation units with the necessary infrastructure and systems to allow for the practice of irrigation.[218] Prior to 2004, irrigation districts were managed by CONAGUA at the national level. After decentralization, management was moved to water user associations.[219] As of 2007, 95 percent of irrigation districts were under decentralized control,[220] where sub-district level water-user associations are able "to manage their own operations, including election of leadership… establishing their own quotas… and setting strategies for reinvestment of those revenues into specific projects that benefit the module."[221] While private individuals are able to apply to CONAGUA for water concessions, a farmer belonging to a user association within an irrigation district will not apply directly to CONAGUA for a water concession but will instead request water from the irrigation district.[222] Irrigation districts may apply directly to CONAGUA for water concessions, but must prove they have appropriate regulations establishing how the water conceded to them will be distributed and administrated, how the rights of the individual water users will be guaranteed and protected, how related infrastructure will be maintained, and how water users will be charged.[223] These regulations are not uniform across districts.

While irrigation units often build and/or maintain the necessary infrastructure for irrigation,[224] CONAGUA also initiates federal improvements of irrigation districts. Water infrastructure investments totaled 2,567 million pesos (181 million USD) in 2007 and 4,000 million pesos (282 million USD) in 2008.[225] The water user associations that make up the irrigation units provided approximately 37 percent of the total investment in both years,[226] a significant increase in the costs paid by irrigators.[227] The transition has thus also disproportionately affected small scale communal farms who have "abandoned active production at an accelerated pace and turned more than ever to land and water leasing to private producers."[228]

Two irrigation districts in the state of Tamulipas border the Rio Grande River, the Río Bravo Irrigation District (025) and the Río San Juan Irrigation District (026).[229] Management of these two irrigation districts was transferred from federal authority to the users in October and November of 1993, respectively.[230] Ten user associations control District 025, while there are thirteen user associations associated with District 026.[231] Both districts use water from the Rio Grande that has been stored in either the Falcon or Amistad reservoirs.[232] In Tamaulipas, approximately 85 percent of the water in these dams is used for irrigation.[233] Irrigation districts in Tamaulipas generally suffer from efficiency problems due to aging and inadequate infrastructure, with an estimated 500 million cubic meters of water wasted each year in the agricultural sector.[234] Approximately 40 percent of the water destined for irrigation is lost between the dam and the agricultural fields in the north of Tamaulipas, where Irrigation Districts 025 and 026 are located.[235] CONAGUA has estimated that 39 billion USD would be necessary to improve the infrastructure. In 2012, Mexico's federal government agreed to invest approximately 9.5 million USD, to be matched by user associations and the state government for a total of 19 million USD.[236]

Endnotes

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[27] National Center for Agricultural Law Research and Information (NCALRI), "State Environmental Laws Affective Texas Agriculture," available at http://www.nasda.org/nasda/nasda/Foundation/state/Texas.pdf.

[28] Texas Water Code, Chapter 26.

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[31] Texas Water Code, Chapter 26.

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[34] As defined in Texas Water Code: "Water" or "water in the state" means groundwater, percolating or otherwise, lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Gulf of Mexico inside the territorial limits of the state, and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or non-navigable, and including the beds and banks of all watercourses and bodies of surface water, that are wholly or partially inside or bordering the state or inside the jurisdiction of the state.

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[38] Ibid.

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[40] Mexican Constitution, Article 27.

[41] National Water Law, Article 20, April 29, 2004.

[42] National Water Law, Article 9.9 and Article 20, April 29, 2004.

[43] Comisión Federal de Mejora Regulatoria, "Concesión de Aprovechamiento de Aguas Subterráneas," CONAGUA-01-004A, 8, available at http://207.248.177.30/buscadorTramites/fichasPDF/modificaciones/CONAGUA-01-004A.pdf.

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[45] National Water Law, Article 21, April 29, 2004.

[46] Ibid.

[47] National Water Law, Article 22, April 29, 2004.

[48] Ibid.

[49] National Water Law, Article 24, April 29, 2004.

[50] "Concesión de aprovechamiento de Aguas Superficiales," 5.

[51] National Water Law, Article 52, April 29, 2004.

[52] National Water Law, Article 51, April 29, 2004.

[53] National Water Law, Article 20.

[54] CONAGUA, "Permiso de descarga de aguas residuales," CONAGUA-01-001, 1-2, http://www.cmp.org/apoyos/cna-01-001.pdf.

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[56] National Water Law, Article 87, April 29, 2004.

[57] "Permiso de descarga de aguas residuales," 4.

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Chapter 3. State of Water Infrastructure in the Lower Rio Grande/Río Bravo

The majority of both the Mexican and U.S. population along the Rio Grande/Río Bravo discharges wastewater effluents into sewers that lead to wastewater treatment systems. Most residents on the U.S. side live within incorporated municipalities in Starr, Hidalgo, and Cameron counties, such as the cities of Roma, Rio Grande City, La Grulla and Brownsville, that have well-developed sewage collection and wastewater treatment. The urban population within the Mexican watershed lives within cities, such as Tamaulipas, Reynosa, Matamoras, Gustavo D. Ordaz, Cuidad Carmargo, and Ciudad Miguel Aleman, that also have built sewage collection and treatment systems.

Along both Mexican and U.S. borders, some residents are still not connected either to central wastewater or to regulated septic systems. Residents may use unregulated septic systems, a covered pit with no treatment features, or a pit privy (an outhouse). These unregulated systems can be a source of direct wastewater discharge into waterways. The Texas Water Development Board's Economically Distressed Areas Program (EDAP) reports that there remain many thousands of colonia residents with inadequate waste control systems. Some of the issues include the absence of sewerage collection, questions as to whether existing septic systems or other on-site systems operate well, and a lack of connections to wastewater collection systems.

On the U.S. side of the lower Rio Grande/Río Bravo, a substantial fraction of the population lives in poor, rural communities, exactly the populations that tend to rely on on-site wastewater systems.[237] In such small communities, septic tanks are the most accepted alternative as residents may not be able to afford the large upfront investment to connect with sewers and wastewater treatment plants. An estimated 25 percent of the U.S. population relies on on-site wastewater systems to treat and dispose of their household waste. Of that number, about 95 percent of the disposal systems are septic tank systems.[238] In Texas, about 18 percent of the total population uses wastewater disposal other than a public sewer. In small Texas communities, with populations less than 10,000, the fraction of the population using wastewater disposal other than a public sewer jumps to 60 percent.[239] Only 2 percent of the small community population has no wastewater treatment at all. Thus, around 58 percent of the residents in small Texas communities, which includes the rural population within the Rio Grande Valley, use septic systems for their wastewater disposal.[240]

Beginning in 1989, the Texas Legislature authorized the Model Subdivision Rules for areas receiving funding under the EDAP.[241] These rules provide for more oversight of colonia building standards, requiring any new developments to include properly installed water supply and septic systems. These rules have since been adopted into the Texas Administrative Code for all developments and have helped reduce the instances of open or improper waste water systems.[242] But problems remain:

> Many colonias do not have sewer systems. Instead, residents must rely on alternative, often inadequate wastewater disposal methods. Surveys of colonias in

El Paso and the Rio Grande Valley show that 50.7 percent of the households use septic tanks, 36.4 percent use cesspools, 7.4 percent use outhouses and 5.5 percent use other means to dispose of wastewater. Septic tank systems, which in some circumstances may provide adequate wastewater disposal, often pose problems because they are too small or improperly installed and can overflow. The problem is exacerbated by the poor quality of colonia roads, which are often unpaved and covered with caliche or other materials that prevent thorough drainage. During heavy rains, water collects because of inadequate drainage systems, elevation and topography. These conditions, combined with inadequate septic tanks, often result in sewage pooling on the ground.[243]

With regard to the Mexican side of the lower Rio Grande/Río Bravo, Table 3.1 lists the portions of the Mexican population with and without wastewater disposal systems. Table 3.2 disaggregates waste disposal by the type of service: public sewers, septic systems, or wastewater discharged via cliffs, rivers or lakes. In 2005, CONAGUA estimated that 2.1 percent of the urban population and 35 percent of the rural population of the country lacked "improved sanitation facilities," defined as "[connection] to the sanitation network or a septic tank, wastepipe, ravine, crevice, lake, or sea."[244] In other words, 35 percent of rural citizens use an alternative on-site treatment method other than a septic tank that is considered by CONAGUA to be less advanced—and less sanitary (not "improved")—than a septic tank. In 2009, 5.77 percent of Camargo's residents discharged their wastewater "into cesspools and/or failing septic tanks."[245] In 2010 in Tamaulipas, 7.6 percent of the population did not have access to conventional sewage treatment, or over 100,000 people in nearly 29,000 households without basic sanitation.[246]

Table 3.1 Population With and Without Sewage in Tamaulipas Municipalities

Number	Municipality	State	With Sewage	No Sewage	Not Specified	Total
1	Guerrero	Tamaulipas	3,712	272	3	3,987
2	Mier	Tamaulipas	4,556	94	78	4,728
3	Los Aldamas	Nuevo León	1,146	190	5	1,341
4	Miguel Alemán	Tamaulipas	25,737	563	137	26,437
5	Doctor Coss	Nuevo León	1,474	189	46	1,709
6	Camargo	Tamaulipas	13,255	1,097	304	14,656
7	General Bravo	Nuevo León	4,760	671	72	5,503
8	Gustavo Díaz Ordaz	Tamaulipas	13,349	2,158	134	15,641
9	Reynosa	Tamaulipas	517,114	28,554	9,587	555,255
10	Río Bravo	Tamaulipas	99,062	17,747	523	117,332
11	Valle Hermoso	Tamaulipas	53,667	8,948	186	62,801
12	Matamoros	Tamaulipas	429,258	43,066	5,419	477,743

Source: INEGI, "Ocupantes de viviendas particulares habitadas por municipio, disponibilidad de energía eléctrica y agua según disponibilidad de drenaje y lugar de desalojo," Censo de Población y Vivienda 2010. Aguascalientes, Aguascalientes, 2010, Excel Spreadsheet, available at http://www3.inegi.org.mx/sistemas/TabuladosBasicos/Default.aspx?c=27302&s=est.; Table reported in Robert Lynch, "GIS-based Estimation of Steady-State Non-Point Source Bacteria Pollution in the Lower Rio Grande below Falcon Reservoir," Master's Report, The University of Texas at Austin, 2012.

The general approach to wastewater collection and treatment in rural areas within the Lower Rio Grande/Río Bravo watershed is to rely on regulated septic systems or less reliable onsite sewage systems.[247] Most Texas rural residents in the Valley operate regulated septic systems, although inspectors periodically discover households on unpermitted systems, such as cesspools or pit privies.[248] Both the Texas and Mexican wastewater programs have been successful in converting rural septic systems to more sustainable methods of wastewater disposal that reduce discharges to surface waters, such as: (a) extending connections of central sewer systems into suburban, exurban or rural areas; (b) increasing the number of households using regulated septic systems; (c) improving septic system technology to reduce failures; and (d) encouraging robust septic inspection and maintenance. Some Mexican residents with access to centralized wastewater service continue to use septic tanks, as in the Mexican city of Reynosa, where "approximately 25 percent of the lots that have municipal sewage services provided continue to dispose of their raw sewage via septic tanks and cesspools."[249]

With regard to installing proper septic systems or hooking communities up to a sewer line, it is an expensive proposition, particularly for poor communities or rural landowners. While the federal and state governments have developed a source of funding for colonias to support water supply and wastewater infrastructure,[250] one challenge for rural residents to connect with central wastewater systems is that the cost to connect is proportional to the community's distance from the urban area that has the central wastewater collection and treatment facilities. Some non-urban areas are so remote that connectivity to central wastewater is impractical. Some rural populations adjacent to urban areas could be connected if funds were available to build the sewage systems.

Other rural wastewater problems are related to design issues, to the volume of flow (too much) or to soil drainage (too little). Inadequate drainage field size or improper soil characteristics (permeability) can cause an otherwise adequate septic system to function improperly. For example, around the City of La Grulla in Starr County, Texas, the soils drain poorly, resulting in "overflows and seepages of wastewater."[251] In fact, the vast majority of Starr County is covered with soils that drain "poorly" or "extremely poorly," making them ill-suited for septic systems.[252] Thus, there can be a conflict between citizen preferences for on-site treatment versus so-called "best" practices. For example, the Texas Administrative Code does not allow septic systems to be installed in Class Ib or Class IV soils, which have the lowest drainage rates.[253]

The Water Treatment Process

There are three phases of a conventional wastewater treatment plant (WWTP), often termed as primary, secondary and tertiary. During primary treatment, heavy solids settle via gravity to the bottom of a basin, while any grease and oil float to the top and can be removed. During secondary treatment, micro-organisms present in the water digest dissolved and suspended biological matter, with the resulting sludge being removed by gravity.

Along the U.S. side of the lower Rio Grande, the so-called activated sludge process is the most common biological treatment process. Both activated sludge and lagoon-based

WWTPs are common in Mexico. Lagoon systems use a series of pond-like bodies to hold and treat wastewater. While activated sludge systems have higher treatment efficiencies, lagoons are cheaper to construct and operate. There are many physical, chemical and biological treatments termed “tertiary,” in that they use chemical, biological or physical processes to remove nutrients or other contaminants, that are options if wastewater is to be reused or discharged into sensitive surface waters.

The conventional means to reduce unwanted bacterial effluents would be to convey wastewater in piped sewers to wastewater treatment or to treat effluents on-site via a regulated septic tank or other on-site system. Universal wastewater coverage could reduce urban wastewater from both the U.S. and Mexican sides of the Rio Grande/Río Bravo. Such infrastructure solutions require capital expenditures. Proper maintenance of collection systems (including inspections of sewer lines and lift stations) can sustain and enhance sewer systems, prevent pipe cracking, collapsing or blockages, which can cause sewer line ruptures.

Septic systems use on-site sewage treatment to convey wastewater to a tank where micro-organisms digest organic matter, with treated overflow distributed into an adjacent drain field in the soil. Septic systems are designed to accommodate a particular wastewater volume and the permeability of the soil to assure waste decomposition. In Texas, the TCEQ along with each county regulates septic systems to assure septic construction follows established practice, are in good working order, and treat wastewater effectively.

Mexican border cities along the Río Bravo have made significant progress in preventing untreated waste from entering the river. Before 1990, fewer than 50 percent of the Mexican population along the Río Bravo were served by sewers.[254] Efforts by CONAGUA (as well as BECC/NADB and CILA) have raised the connection rate (people connected to public sewer service) to 67.6 percent by 2005.[255] Mexican communities, like their U.S. counterparts, face a challenge of maintaining and improving existing central wastewater treatment infrastructure while simultaneously seeking to implement plans to expand central wastewater coverage as the population grows. Table 3.2 lists wastewater projects that have been completed, proposed, planned, or are under construction in Mexico’s lower Río Bravo Valley that discharge into the Río Bravo. Over the past 20 years, nine WWTPs have been placed into operation, proposed, planned, or are under construction in the Lower Rio Grande Valley on the U.S. side (see Table 3.3).

Within segments 2301 and 2302, the TCEQ has issued 81 Certificates of Convenience (CCNs) in Starr, Cameron, Hidalgo and Willacy Counties for wastewater treatment. Only six of those CNNs discharge to the Rio Grande: Rio Grande City, Union Water Supply Corporation, Agua Special Utility District, the City of Peñitas and the City of Brownsville. The border cities of Roma and La Joya also have permits to discharge wastewater into the Rio Grande. As only eight can discharge into the Rio Grande, the vast majority of wastewater generated from U.S. border county residents downstream of Falcon Reservoir is discharged not into the Lower Rio Grande but to the Arroyo Colorado, the watershed located directly to the north of the lower Rio Grande.

Table 3.2 Type of Sewage Control in Mexican Municipalities

Number	Municipality	State	Public Sewage	Septic Tank	Piping that goes to a cliff or crevice	Piping that goes to river, lake, or sea	Subtotal
1	Guerrero	Tamaulipas	3,272	438	2	0	3,712
2	Mier	Tamaulipas	4,455	101	0	0	4,556
3	Los Aldamas	Nuevo León	4	1139	3	0	1,146
4	Miguel Alemán	Tamaulipas	21,781	3,877	28	51	25,737
5	Doctor Coss	Nuevo León	7	1467	0	0	1,474
6	Camargo	Tamaulipas	7,949	5,205	72	29	13,255
7	General Bravo	Nuevo León	914	3846	0	0	4,760
8	Gustavo Díaz Ordaz	Tamaulipas	4,050	9,290	4	5	13,349
9	Reynosa	Tamaulipas	464,858	51,943	144	169	517,114
10	Río Bravo	Tamaulipas	85,886	13,066	92	18	99,062
11	Valle Hermoso	Tamaulipas	50,311	3,004	293	59	53,667
12	Matamoros	Tamaulipas	398,730	29,866	419	243	429,258

Source: INEGI, "Viviendas particulares habitadas por municipio, disponibilidad de energía eléctrica y agua según disponibilidad de drenaje y lugar de desalojo," Censo de Población y Vivienda 2010. Aguascalientes, Aguascalientes, 2010, Excel Spreadsheet, available at http://www3.inegi.org.mx/sistemas/TabuladosBasicos/Default.aspx?c=27302&s=est; Table reported in Robert Lynch, "GIS-based Estimation of Steady-State Non-Point Source Bacteria Pollution in the Lower Rio Grande below Falcon Reservoir," Master's Report, The University of Texas at Austin, 2012.

Table 3.3 Camargo's Wastewater Collection System

Current Problems

- Twenty-four percent of the total population of Camargo (in Villanueva, La Mision, Ejido, Gonzaleño and Colonia El Sauz) discharge wastewater into cesspools.
- The main wastewater collector in Camargo has seen repairs repeatedly since 1998, but has never worked properly because of construction problems.
- The existing lagoon-based wastewater treatment system does not discharge any treated effluent, indicating the possibility of subsurface wastewater infiltration.
- The capacity of the existing wastewater collection system is inadequate for the current volume of generated wastewater.
- An increase in Camargo's population over the next 20 years will put an additional strain on the system.

Possible Improvements

- Proposed $1.75 million for wastewater collection system improvements and expansion.
- Extend collection coverage to unserved areas that include 2,500 new users.
- Reroute and redesign the force main to the existing wastewater treatment lagoons.
- Replace pipeline.
- Install additional manholes.

Source: Ninyo and Moore, "Improvements to the Wastewater Collection System for Camargo, Tamaulipas, Mexico," Transboundary Environmental Information Document, El Paso, Tex., August 14, 2009.

Several communities have also sought to reduce long-term costs by utilizing solar power. For example, a water and wastewater project in San Benito, Cameron County, Texas, received a $325,000 grant from the Texas General Land Office's Sustainable Energy Project (funded by EPA Region 6 through the Border Environment Infrastructure Fund). The system, intended as an example of solar energy for wastewater treatment within the border region, uses photovoltaic solar panels to provide approximately 10 percent of the electricity to run the treatment plant. Although approximately 28,000 residents used the system in 2009, the San Benito project includes a new 3.5 million gallon per day WWTP designed to treat the wastes of approximately 43,500 people by 2030.[256]

One approach to reducing inadequate wastewater infrastructure for border region colonias in Starr, Hidalgo and Cameron Counties has been to develop and implement plans to extend existing municipal wastewater treatment capacity to connect colonias to central treatment facilities. In Starr County, these large-scale projects have included a $29 million City of Roma Colonias Water and Wastewater Improvement Project initiated in 1997 and completed in 2007, a $1.3 million Rio Grande City Water and Wastewater Project initiated in 1995 and completed in 2002, and a project in La Grulla that has yet to secure full funding.[257]

Camargo, Tamaulipas is a case that illustrates barriers within Mexico to universal wastewater treatment in the Río Bravo basin. Camargo's WWTP includes five oxidation earthen lagoons that treat 0.46 millions of gallons per day (mgd).[258] Table 3.3 lists the current challenges to Camargo City's wastewater collection system, including issues of money, technology, maintenance, operations, planning and management, and the proposed improvements.

Endnotes

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Chapter 4. Water Quality in the Lower Rio Grande/Río Bravo and Sources of Contamination

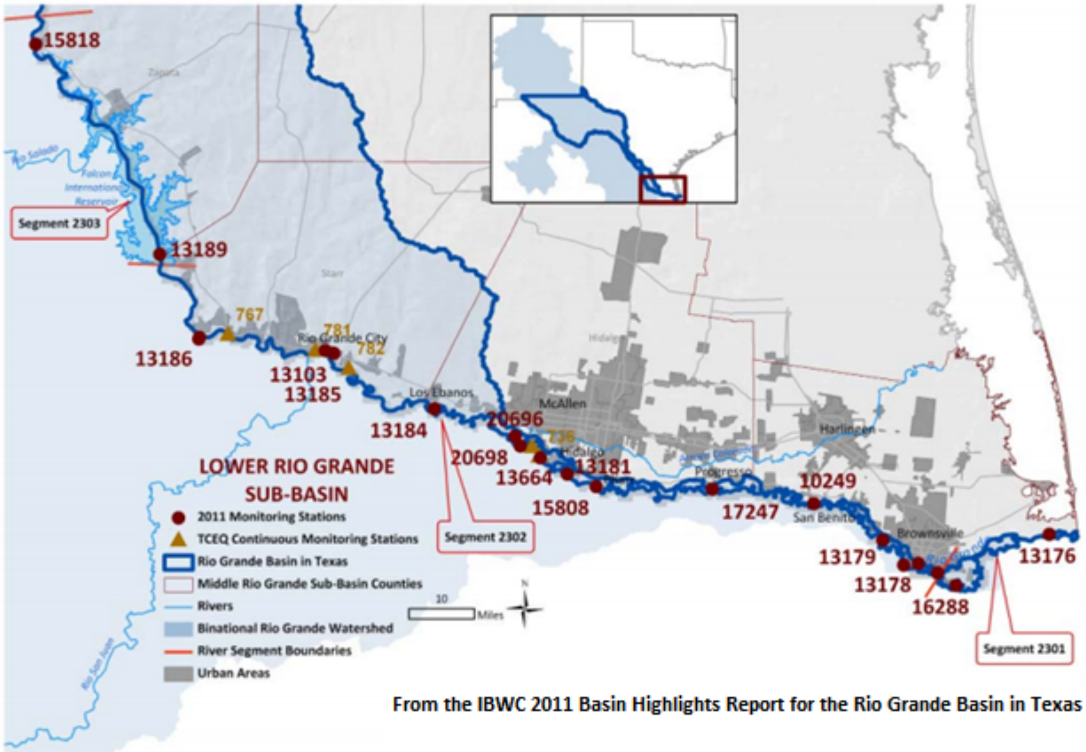
The Lower Rio Grande/Río Bravo is the primary water source for diverse water uses in both Mexico and Texas along the border between the Mexican State of Tamaulipas and the Texas counties of Cameron, Hidalgo, and Starr. Waste discharge from wildlife, as well as human water users (domestic and commercial customers, ranch and farm producers, and industry), limit the river's uses for contact recreation. This chapter describes the diversity and intensity of water quality issues in the 280 miles between the dam at the International Falcon Reservoir south of Nuevo Laredo to the Gulf of Mexico. The included figures illustrate changes in monitored contaminant levels over the past 25 years, as measured by the TCEQ for the two monitoring sites in Segment 2301 and the 23 monitoring sites in Segment 2302. Descriptions of the pollution and the consequences of each type of pollution in the Rio Grande/Río Bravo are discussed.

The Texas Commission on Environment and Quality (TCEQ), the International Boundary and Water Commission, U.S. Section (USIBWC) and the Comisión Nacional del Agua (CONAGUA) manage 23 water-quality monitoring stations along segments 2301 and 2302 quality.[259] The TCEQ refers to the region either as the "Lower Rio Grande Valley" or as Rio Grande Segments 2301 and 2302. Segment 2302 begins at Falcon Dam in Starr County and continues to a point 6.7 miles (10.8 km) downstream of the International Bridge in Cameron County. Segment 2301 starts at the end of 2302 and continues to the confluence with the Gulf of Mexico. Figure 4.1 indicates the placement of water quality monitoring stations in the Lower Rio Grande/Río Bravo Basin.

Both segments of the Rio Grande/Río Bravo provide water for domestic use, farming, and ranching, as well as recreational uses such as fishing, swimming, and canoeing. Tests on these river segments consistently indicate that bacteria levels in the water in both segments exceed Texas' upper limits on bacteria for recreational use. The IBWC also has identified additional concerns in the river, such as low dissolved oxygen (DO) and high ammonia, chlorophyll-a, phosphorus, and nitrate levels. Mercury has been found in fish in portions of the river.[260]

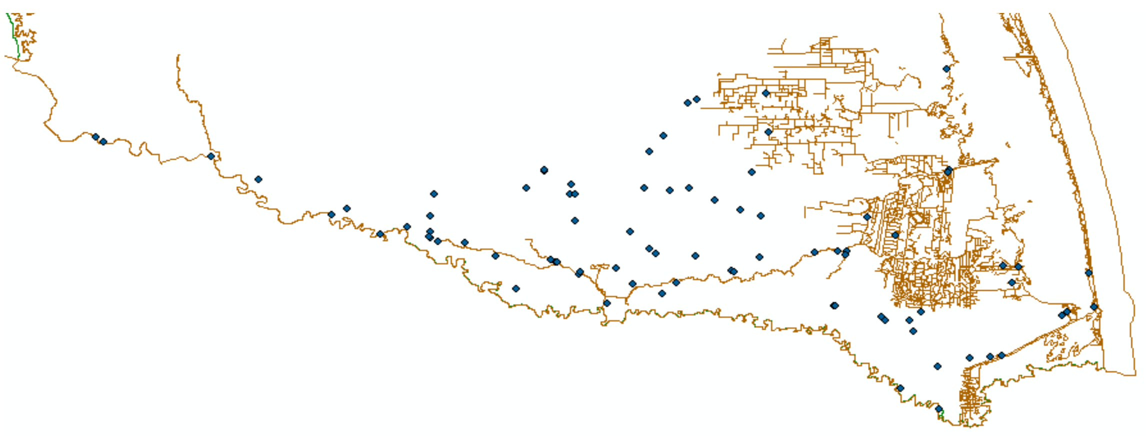
Agencies responsible for water quality in both Mexico and the U. S. have sought to improve the regional water quality. For example, many municipalities use Rio Grande water but discharge wastewater into the Arroyo Colorado.[261] Figure 4.2 illustrates wastewater outfalls in the region relevant to stream segments, Figure 4.3 shows outfalls in relation to county lines, Figure 4.4 indicates only those outfalls that discharge to the Rio Grande, and Figure 4.5 identifies the monitoring sites in blue and the wastewater outfalls in red.[262]

Figure 4.1 Lower Rio Grande Basin Station Map



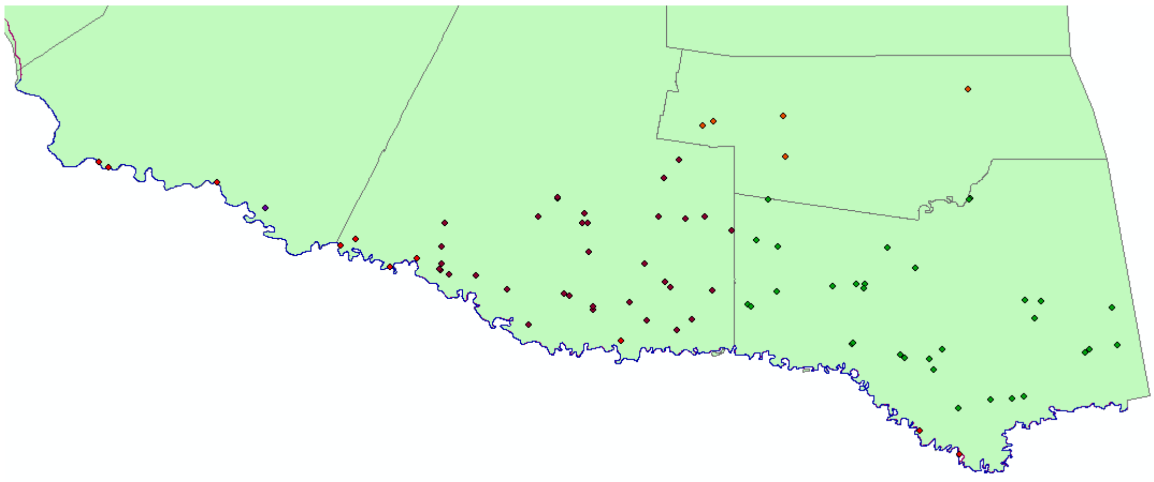
Source: IBWC, Texas Clean Rivers Program, U.S. Section, "2011 Basin Highlights Report for the Rio Grande Basin in Texas," available at http://ibwc.state.gov/CRP/documents/USIBWC_2011BHR_final.pdf April 2011, 37, accessed March 21, 2012.

Figure 4.2 Lower Rio Grande Wastewater by Stream Segments



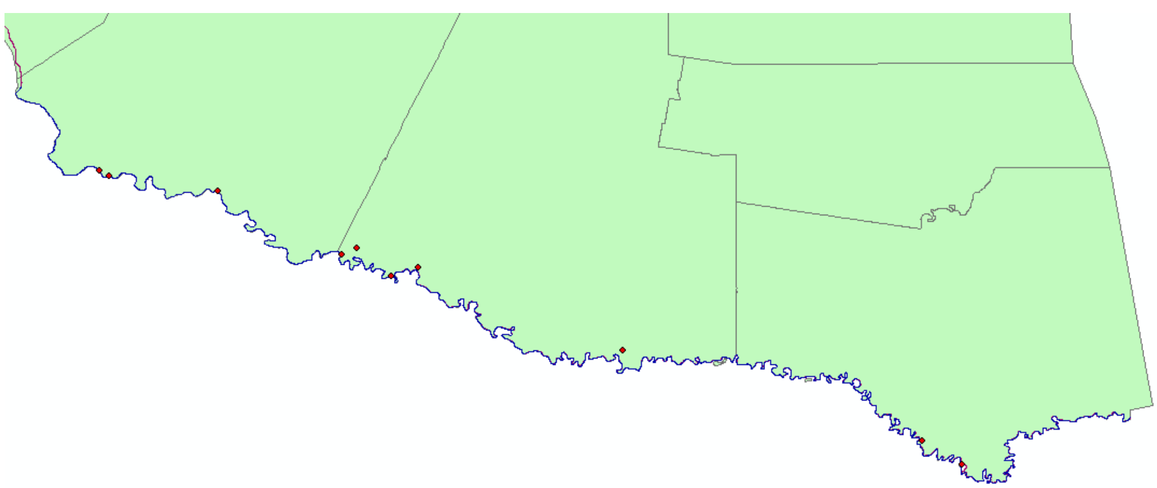
Source: Developed by participants in the Lower Rio Grande/Río Bravo Water Quality Management Project, data found in publicly available TCEQ records.

Figure 4.3 Lower Rio Grande Wastewater Outfalls by County



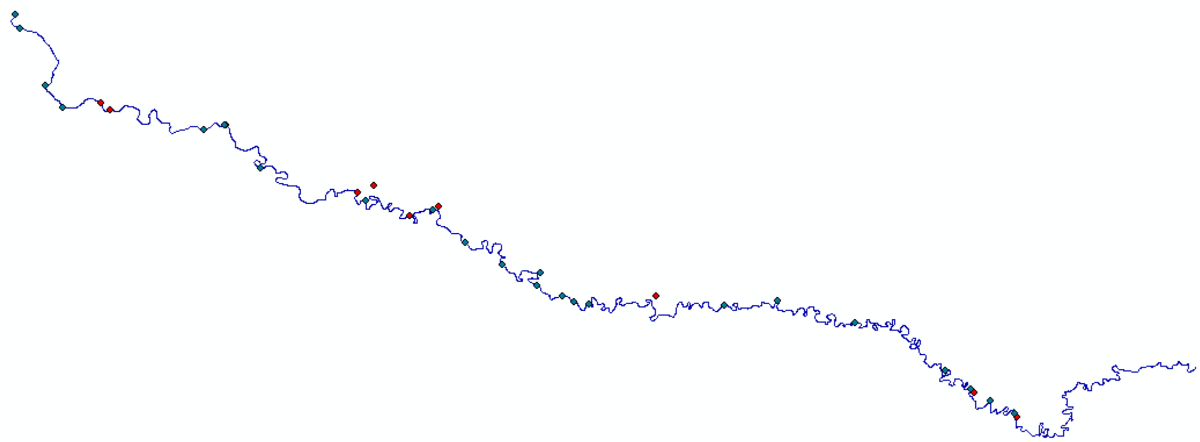
Source: Developed by participants in the Lower Rio Grande/Río Bravo Water Quality Management Project, data found in publicly available TCEQ records.

Figure 4.4 Wastewater Outfalls that Discharge to the Rio Grande/Río Bravo



Source: Developed by participants in the Lower Rio Grande/Río Bravo Water Quality Management Project, data found in publicly available TCEQ records.

Figure 4.5 Lower Rio Grande Wastewater Outfalls and Monitoring Sites



Source: Developed by participants in the Lower Rio Grande/Río Bravo Water Quality Management Project, data found in publicly available TCEQ records.

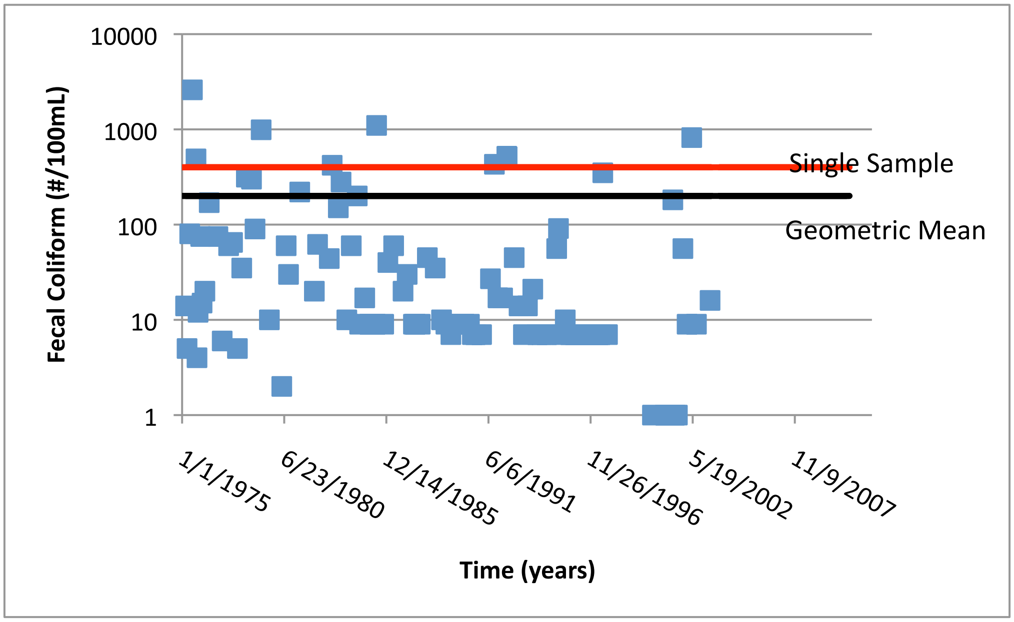
Bacteria, Fecal Coliform, and E. coli

The TCEQ has named bacteria as a persistent impairment in both Segment 2301 and Segment 2302 of the Rio Grande/Río Bravo. If a person ingests bacteria-contaminated water during recreational water activities like swimming, the water can cause stomach and bowel discomfort, diarrhea, vomiting, or abdominal cramps.[263] Contact with contaminated water can also cause infections of the throat, eye, nose or ears.[264] These symptoms are generally not life threatening and will usually clear up in a couple days for most individuals. However, these conditions can be life-threatening to infants, people with weak immune systems, or the elderly.[265] A person's risk of getting sick increases when he or she comes into contact with an impaired water body. Neither people nor pets should ingest the water from a water body with a bacterial impairment.

Bacterial contamination is monitored in water via indicator organisms such as fecal coliform. Fecal coliform and other bacteria themselves are not necessarily infectious; instead, they indicate the presence of other disease-causing contaminants. Where fecal coliform flourish, other contaminants may follow. High levels of fecal coliform bacteria may indicate the presence of pathogenic organisms like protozoa or viruses, which can cause diseases such as dysentery, cholera, hepatitis A, and typhoid fever.[266]

Only one monitoring site in Segment 2301 has fecal coliform data, as indicated in Figure 4.6 that illustrates all of the single sample tests since 1975.[267] For river water testing, the TCEQ single sample limit on the count of fecal coliform colonies (CFUs) ought not to exceed 400 colonies on a membrane filter per 100 milliliters (ml) of river water sampled.[268] The geometric mean is not relevant for single samples, as it is the mean of multiple tests. The high levels of bacteria in the past indicate a persistent problem in the river and a limitation for any recreational water use.

Figure 4.6 Fecal Coliform, Monitoring Station 13176, Segment 2301

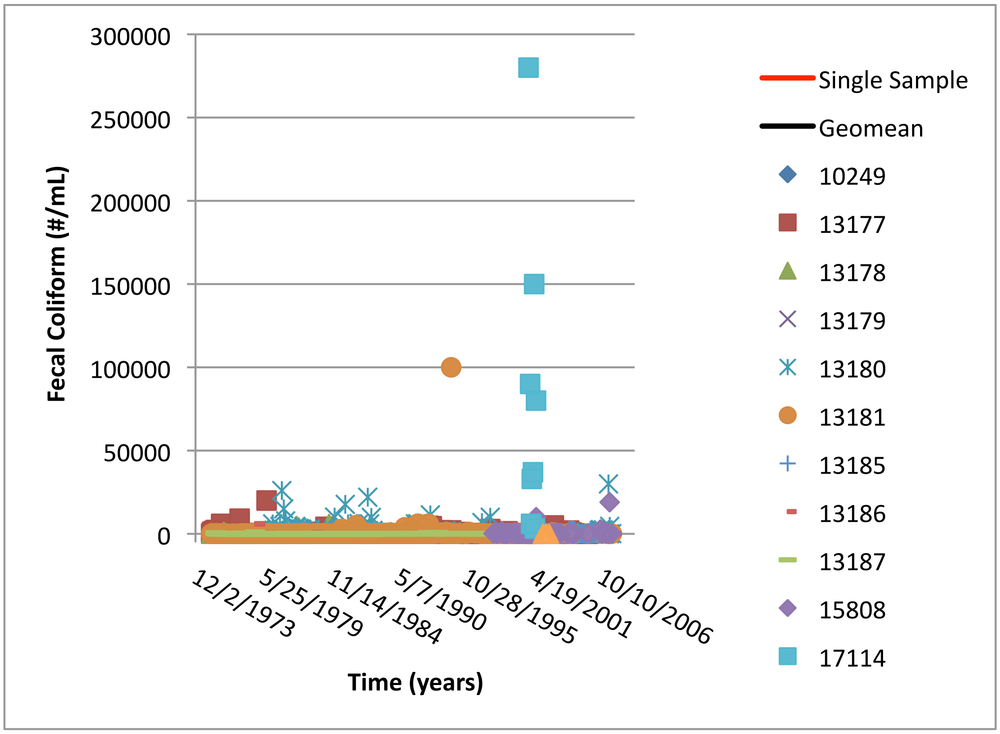


Source: TCEQ, "Selective Data Report for Segment 2301," 2011.

The TCEQ operates 12 monitoring sites collecting fecal coliform data in Rio Grande Segment 2302.[269] Levels of bacteria monitored at Stations 13181 and 17114, at 100,000 to 280,000 CFUs, exceed the maximum allowable coliforms (see Figure 4.7).[270] Figure 4.8 shows a more detailed view of those samples compared with the single sample criterion for reference. Measured fecal coliform at most monitoring sites exceed the standard. The high levels of bacteria at many sites along the river indicate a prevalent problem in the river, not just at one particular site. Given the high fecal coliform levels at various points along the river, it is difficult to identify a particular cause.

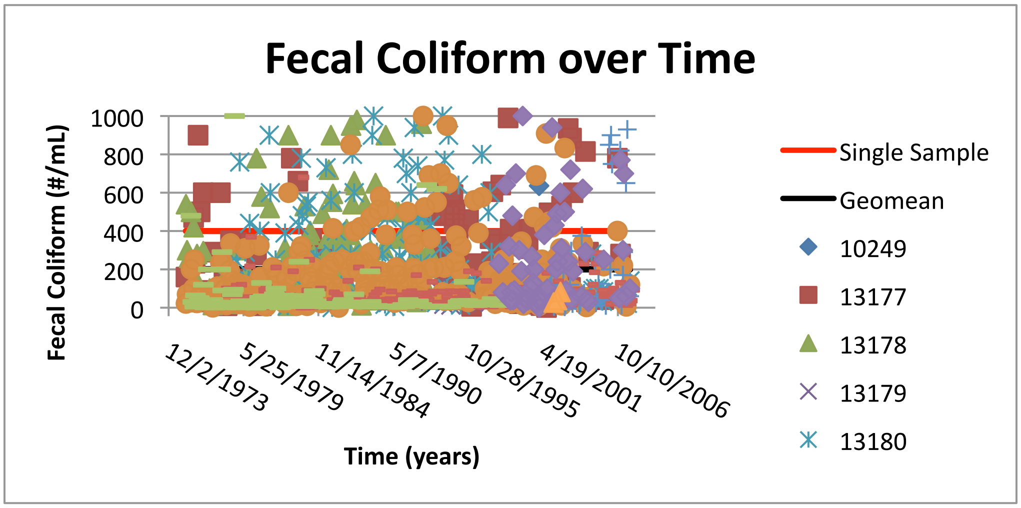
Since 2000, the TCEQ also monitors Escherichia coli (E. coli) as another indicator of impairment at two monitoring sites in segment 2301 and at 14 sites in segment 2302. The single TCEQ upper limit on E. coli colonies per 100 ml of river water is 394 CFUs. Monitoring at both sites in segment 2301 have observed E. coli levels much higher than the single sample limit over the last 10 years (see Figure 4.9).[271] Site 16288 has more samples that surpass the maximum allowable limit than does site 13176. High E. coli concentrations have the same potential risk as high fecal coliform, as both indicate a risk of disease-causing pathogens.

Figure 4.7 Fecal Coliform at 12 Monitoring Stations in Segment 2302



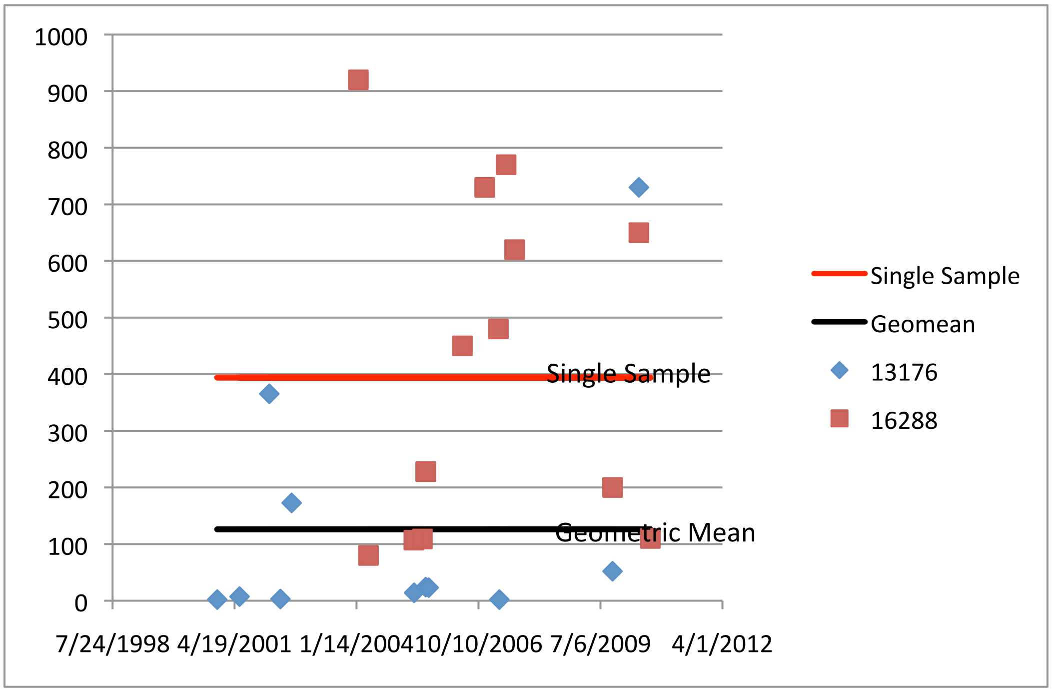
Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Figure 4.8 Fecal Coliform in Segment 2302, Detailed View



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Figure 4.9 E. coli Data in Segment 2301



Source: TCEQ, "Selective Data Report on Segment 2301," 2011.

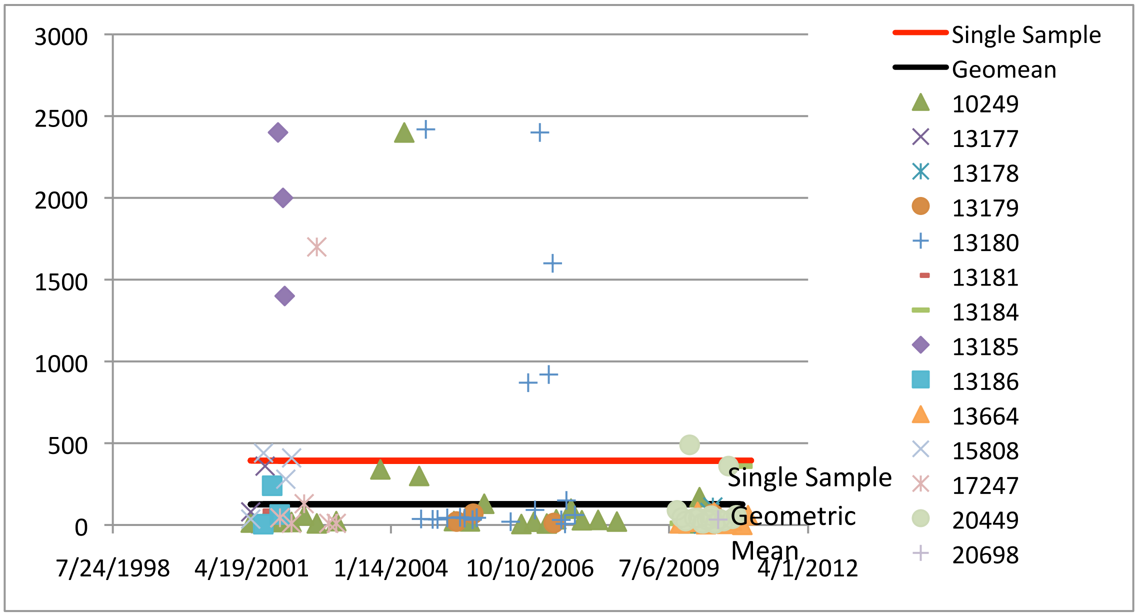
Figure 4.10 illustrates that E. coli levels over the last 10 years at six monitoring sites in segment 2302 have tested much higher than the single sample limit.[272] At three other sites E. coli levels higher than the geometric mean have been measured, which is an indicator of concentrations approaching impairment. E. coli data from all tested sites (see Figure 4.11) indicate recreational use impairment in six sites.[273]

Salinity

Salinity, the amount of salt in the water, is an issue at some sites in the Lower Rio Grande River. Salinity can be problem when high salt content affects agriculture or other water uses, as salinity in water and soils can reduce crop productivity and corrode machinery and pipes. Salinity is monitored via specific conductivity, a gauge of how water transmits an electrical current, which measures the amount of cations, or dissolved salts, in natural waters. The parameter is measured by inserting two electrodes in a sample of water and recording the current that passes between them, as referenced in units of micro Siemens per centimeter (μS/cm).[274]

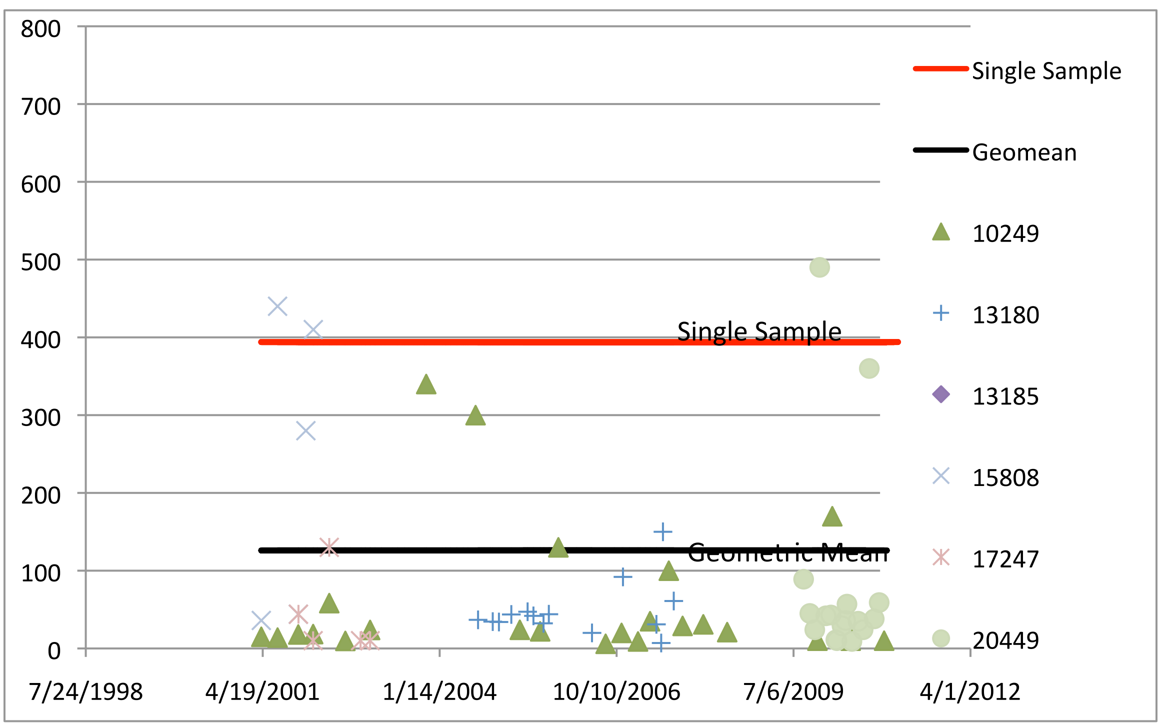
The Texas Clean Rivers Program (CRP) has named salinity as a concern in the lower Rio Grande because of the high salinity measured in the past. For example, in segment 2301, specific conductance has been measured at levels exceeding 11,000 μS/cm (at site 16288) and at levels exceeding 33,000 μS/cm (at site 13176) as shown in Figure 4.12.[275]

Figure 4.10 E. coli Data for 14 Monitoring Stations in Segment 2302



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

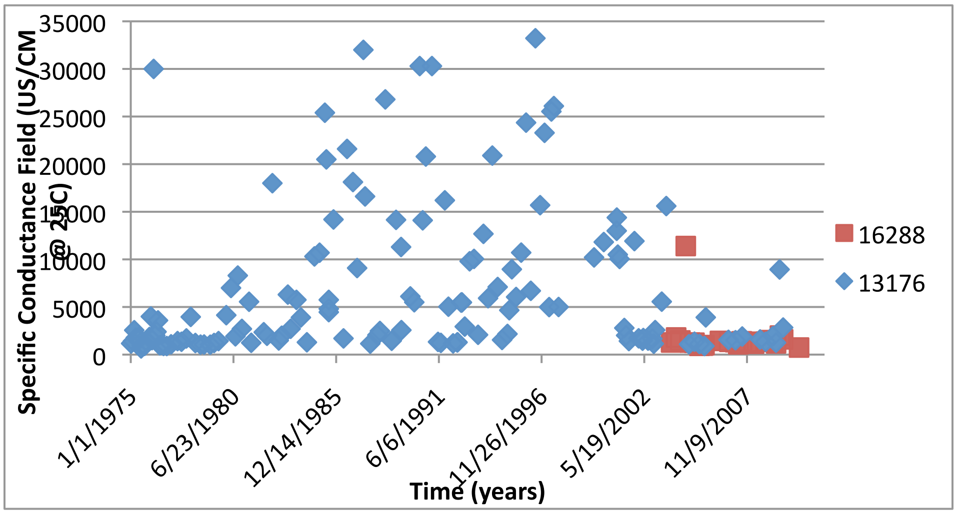
Figure 4.11 E. coli Data Levels in Segment 2302



Source: TCEQ, “Selective Data Report on Segment 2302,” 2011.

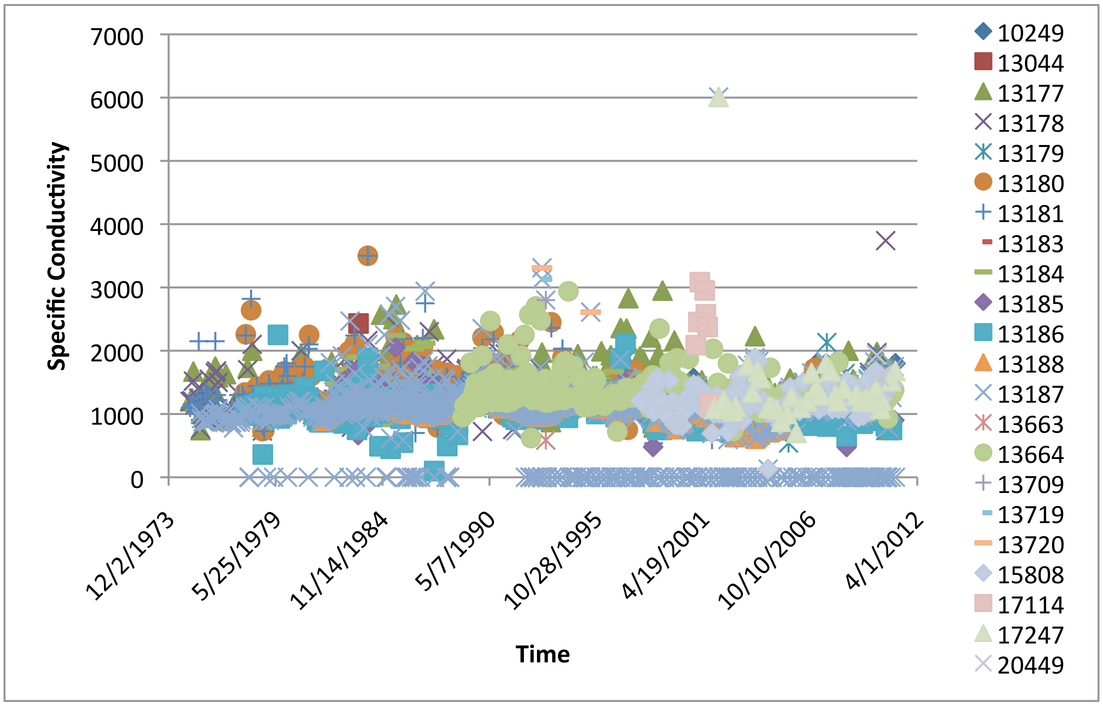
These measures of conductance correspond to salinity measures of 2,600 ppm and 6,200 ppm, respectively. Segment 2301 has higher salinity concentrations, influenced by its location and adjacent to the saline waters of the Gulf of Mexico (see Figure 4.13).

Figure 4.12 Specific Conductivity in Segment 2301



Source: TCEQ, “Selective Data Report for Segment 2301,” 2011.

Figure 4.13 Specific Conductivity in Segment 2302



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

As of 2012, the TCEQ had not established salinity standards in the Lower Rio Grande.[276] Although neither Texas nor Mexico has established salinity standards, Minute 242 of the International Boundary Water Commission has a set salinity standard for the Colorado River that acts as a border between the U.S. and Mexico between Arizona/California/Baja California.[277] According to Minute 242, the U.S. is obligated to deliver water to Mexico upstream of Morales Dam with an annual average salinity of no more than 115 ± 30 ppm (U.S. count) and 121 ± 30 ppm (Mexico count) over the annual average salinity in the Colorado River waters that arrive at Imperial Dam.[278] Should Mexico and the U.S. wish to develop a performance level for salinity standards in the future, Minute 242 sets a precedent for the Lower Rio Grande/Río Bravo.

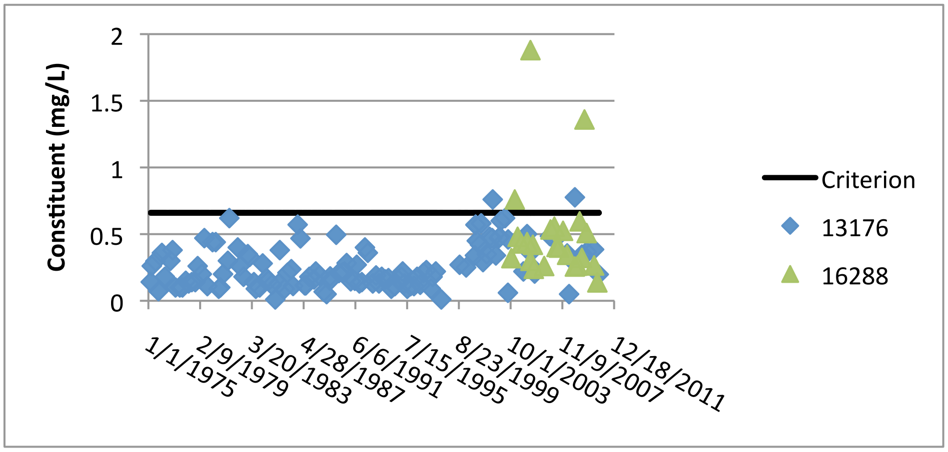
Phosphorus

Phosphorus is an essential nutrient in cells, although high phosphorus levels in natural waters can encourage the growth of plants and other organisms, specifically algae. Algae contribute oxygen to a river in daylight via photosynthesis, converting light energy, water, and carbon dioxide to sugar and oxygen. However, once available nutrients are depleted at night, with light energy no longer available, algae can die and begin decomposing, using up the available oxygen in the river through bacterial respiration. A high level of phosphorus can enhance oxygen depletion in a river, and a low level of oxygen is detrimental to aquatic life and often leads to fish kills.[279]

The TCEQ has established upper limits of phosphorus levels at 0.66 mg/l.[280] Over the last decade, phosphorus levels have exceeded the upper limit at both monitoring stations in segment 2301 (see Figure 4.14) and at six monitoring stations in segment 2302 (see

Figures 4.15 and 4.16). Segment 2301 has had more phosphorus issues than segment 2302 over the last ten years.[281]

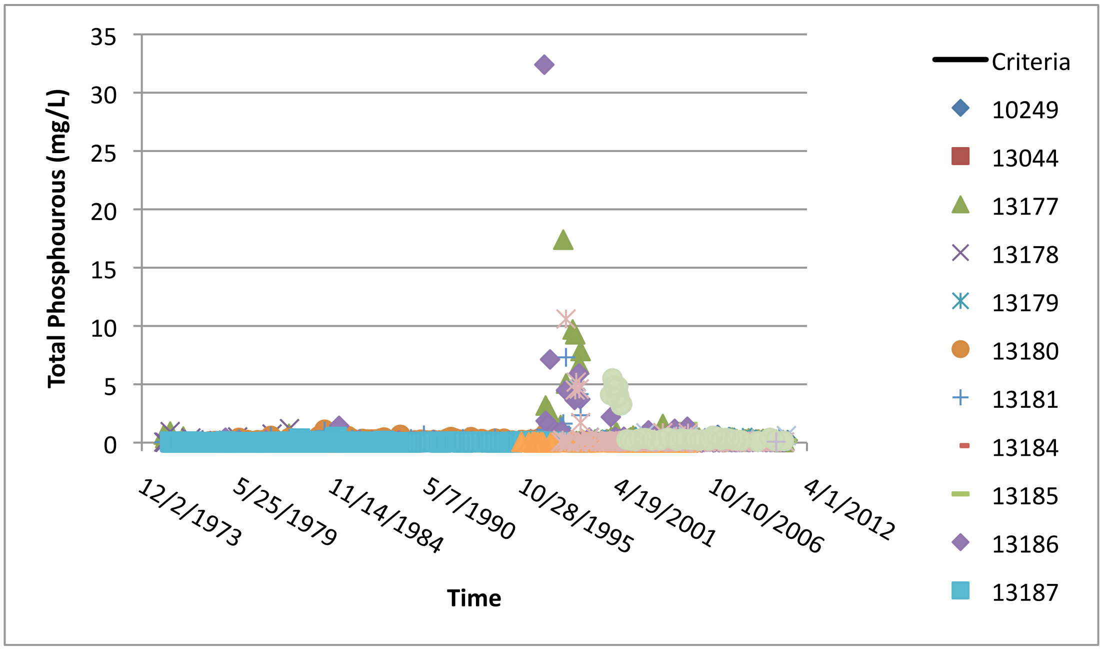
Figure 4.14 Total Phosphorus in Segment 2301



Source: TCEQ, "Selective Data Report for Segment 2301," 2011.

Both monitoring sites in 2301 have recorded concentrations well above the effluent discharge limit; site 16288 has the higher phosphorus concentrations. Measurements in Segment 2302 at ten monitoring stations have exceeded the TCEQ phosphorus criterion in the past thirty years, as illustrated by the monitoring history.[282] A large spike in phosphorus concentrations occurred in the 1990s in segment 2302 (see Figure 4.15) but phosphorus concentrations have fallen over the last decade (see Figure 4.16) and have not exceeded the single sample criterion since 2005.

Figure 4.15 Total Phosphorus Data, Segments 2302

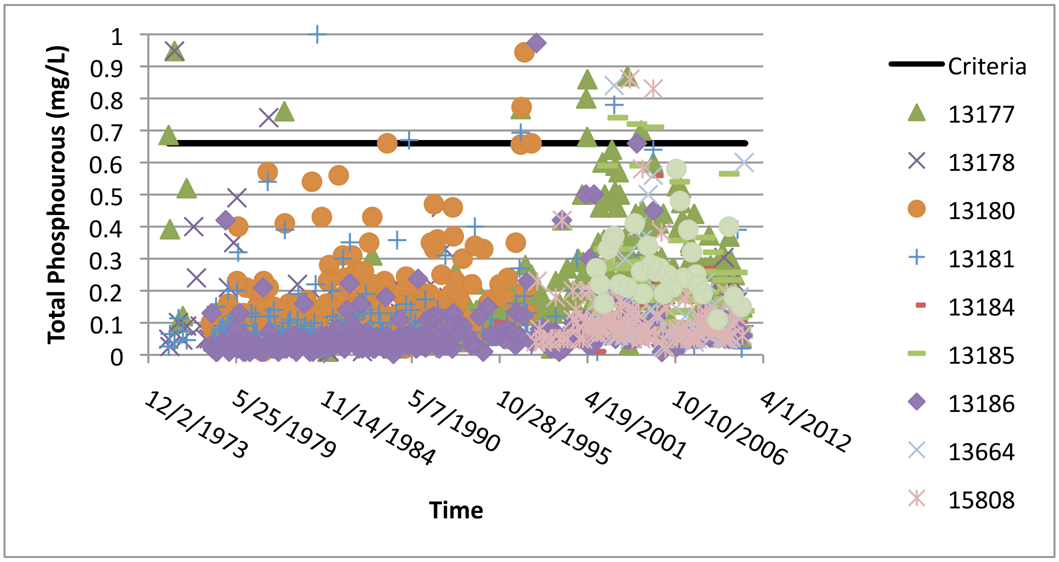


Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Ammonia

The TCEQ has established an upper limit of ammonia at 0.33 mg/l.[283] Increased levels of ammonia in the Rio Grande/Río Bravo can cause stress in fish and damage to their gills and tissues and can be toxic for fish at high levels. Even at low levels, ammonia causes fish to become more susceptible to bacterial infections. An increase in bacterial infections may also increase the growth of bacteria as a whole.[284] In effect, ammonia also may be contributing to sustained bacterial growth in the river.

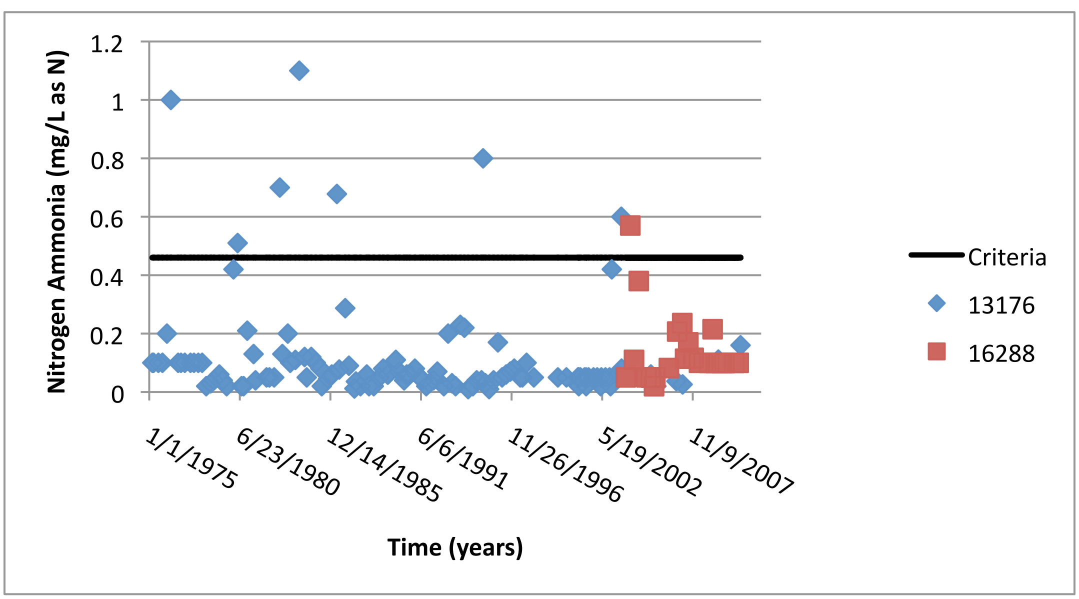
Figure 4.16 Phosphorus Data From 10 Monitoring Stations



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Ammonia levels have exceeded the TCEQ criterion of 0.33mg/l at both stations in segment 2301 in the last decade.[285] The most recent spike in ammonia concentrations occurred almost 10 years ago (see Figure 4.17) and ammonia levels have decreased to an acceptable level since that time.

Figure 4.17 Ammonia Data from Monitoring in Segment 2301

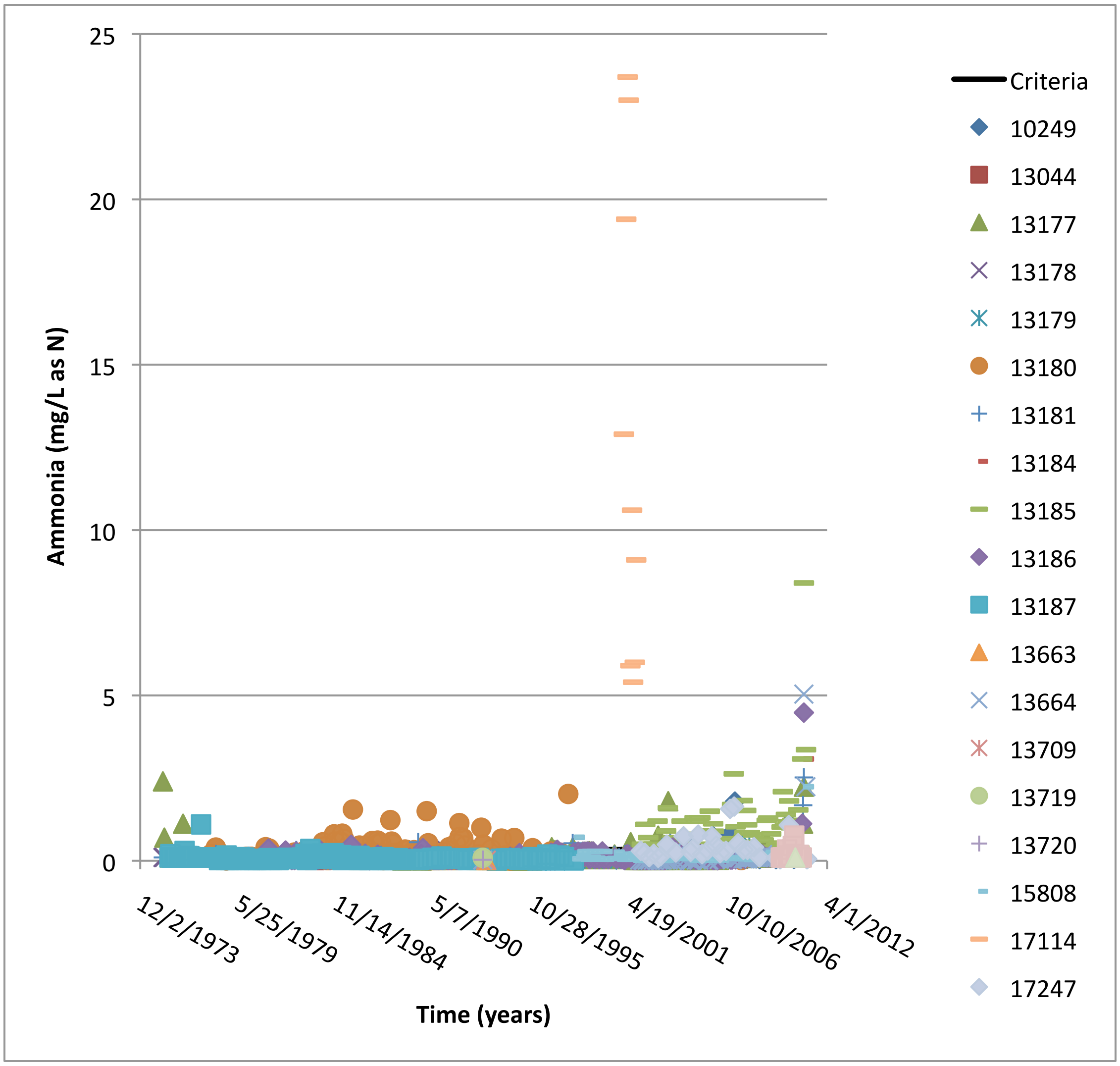


Source: TCEQ, "Selective Data Report for Segment 2301," 2011.

In segment 2302, total ammonia levels have exceeded the TCEQ criteria many times in each of 14 of the 16 monitoring stations that tracked ammonia levels (see Figures 4.18

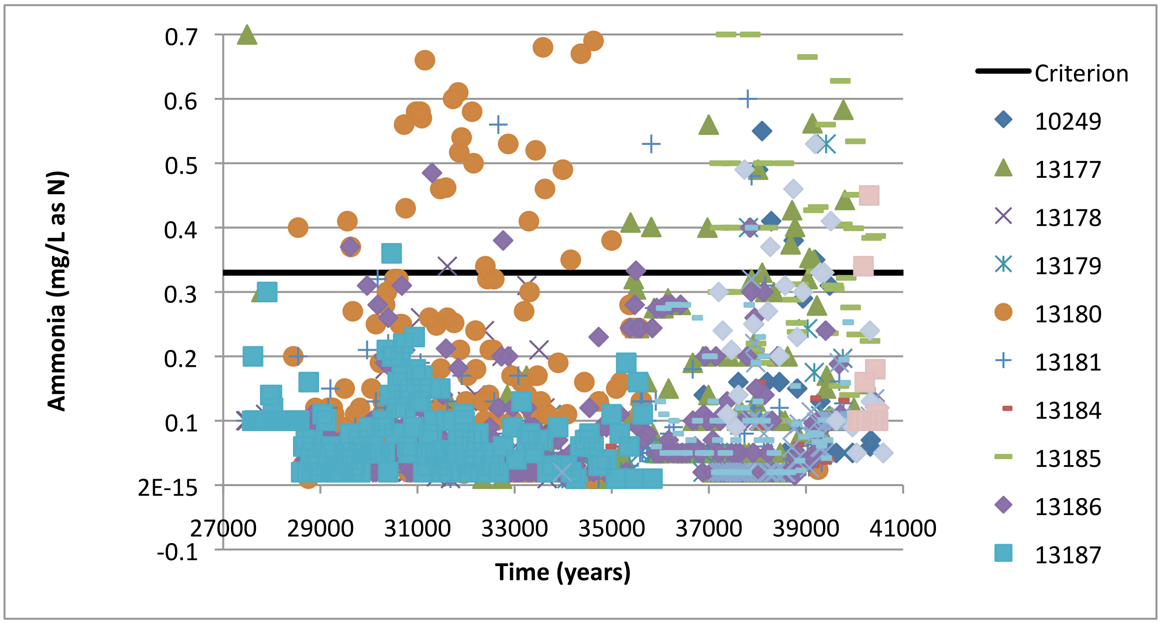
and 4.19).[286] Over the last decade, some stations have monitored lower ammonia levels. Others stations have measured huge spikes to more than one hundred times the maximum allowable concentration (see site 17114 in Figure 4.18). Figure 4.19 shows a closer view of the 14 sites that have exceeded the ammonia criterion.[287]

Figure 4.18 Ammonia From 16 Monitoring Stations in Segment 2302



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Figure 4.19 Ammonia in Segment 2302



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

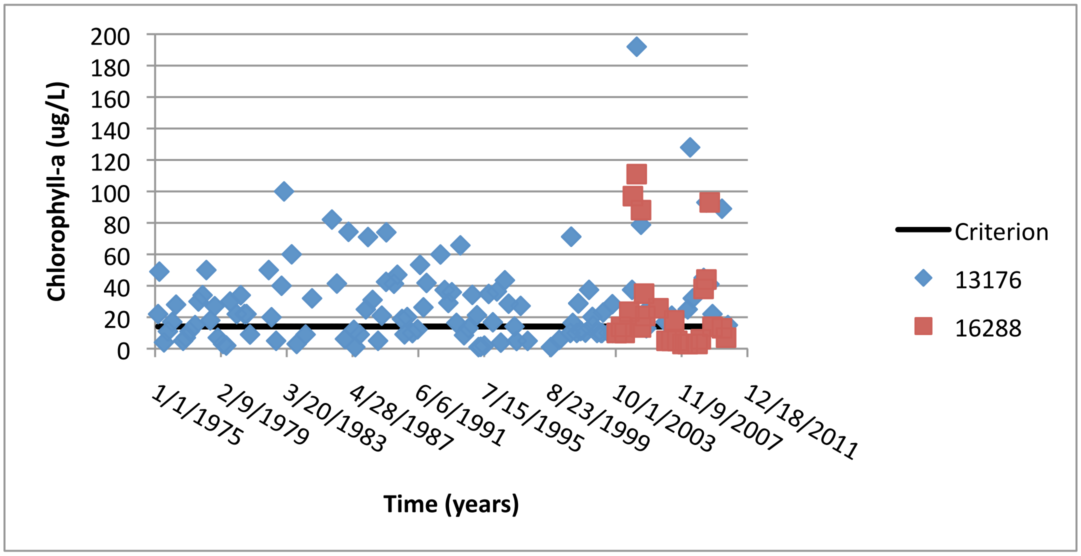
Chlorophyll-a

Chlorophyll-a is essential for photosynthesis and thus is an indicator of photosynthetic growth of plants and algae in a river. High photosynthetic growth levels also indicate high nutrient levels being added to the river via wastewater or run-off from fertilizers. Heavy algae growth and may affect taste and odor of water withdrawn from the river for drinking water, even after treatment. The TCEQ ambient criterion is 14.1 micro grams per liter (ug/l).[288] In both Segment 2301 and Segment 2302 the chlorophyll-a levels exceed the TCEQ criterion (see Figures 4.20 and 4.21). As shown, the high chlorophyll-a concentrations in segment 2301 have been occurring as long as testing has occurred. Chlorophyll-a levels at most of the sites in 2302 have exceeded the criterion over the last couple decades.

Causes and Sources of Contamination in the Rio Grande/Río Bravo

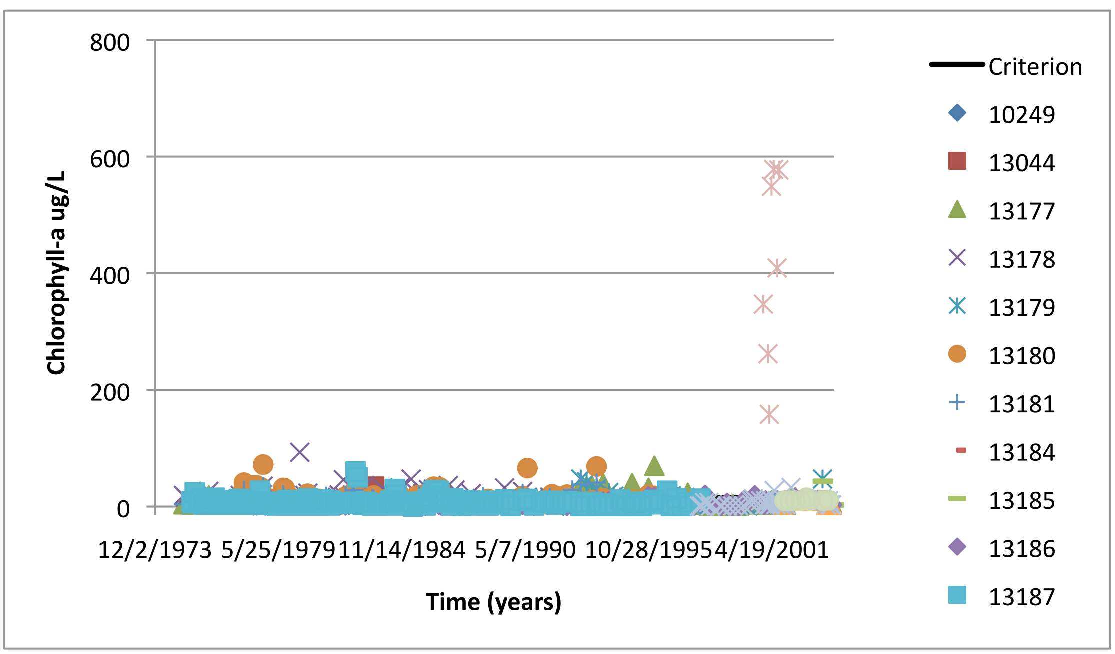
The contaminant sources in the Lower Rio Grande River include both point and non-point sources within Mexico and the United States. The term "point source" refers to discharge outfalls where pollution enters at a single point in space that can be measured directly, such as municipal or industrial waste released from a pipe. The point sources that contribute to river contamination in the lower Rio Grande/Río Bravo between Falcon Reservoir and the Gulf of Mexico include wastewater treatment plants, septic tank leaks, and direct discharge to the river. The term "non-point source" refers either to an effluent source that flows from an area and not a point or rainfall runoff from watershed areas whose sources cannot be identified or measured directly. Non-point sources in the region include leaks from wastewater conveyance systems, animal wastes, human and animal contact with the river or agricultural runoff.

Figure 4.20 Chlorophyll-a Data in Segment 2301



Source: TCEQ, "Selective Data Report for Segment 2301," 2011.

Figure 4.21 Chlorophyll-a Data in Segment 2302



Source: TCEQ, "Selective Data Report for Segment 2302," 2011.

Wastewater Treatment Plants

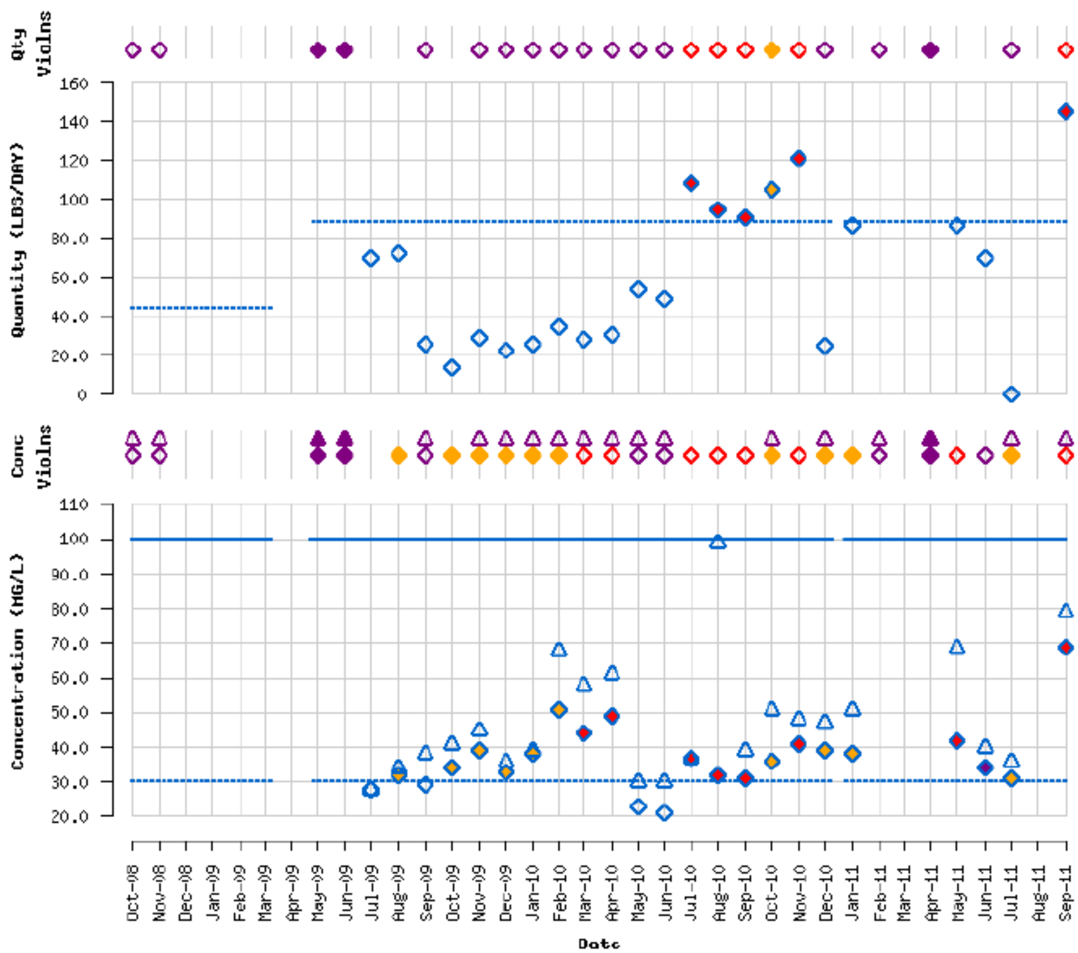
For a wastewater treatment plants to operate on the United States side of the Rio Grande it must obtain a TCEQ Texas Pollutant Discharge Elimination System (TPDES) permit to discharge treated domestic wastewater into or adjacent to a river.[289] Industrial facilities that discharge wastewater into the Rio Grande also must obtain an individual industrial wastewater permit.[290] Four wastewater plants from the U.S. side that discharge into the Rio Grande directly are the City of Roma Wastewater Treatment Plant (WWTP), Rio Grande City WWTP, La Joya WWTP, and Southside WWTP in Brownsville.

Texas regional wastewater treatment plant effluents on occasion have not met TCEQ standards for natural waters,[291] as discussed below. The effluent problems include ammonia, mercury, coliform, fecal coliform, E. coli, dissolved oxygen, biochemical oxygen demand (BOD), and solids. Brownsville recently had two events where ammonia discharges exceeded the set permit limits. Three wastewater treatment plants on the U.S. side of the Rio Grande/Río Bravo discharged levels of mercury above their criteria; the wastewater plants from Rio Grande City and La Joya each had one high concentration instance while that from Southside in Brownsville had three.[292] On two occasions Rio Grande City released coliform levels in their effluent above Texas standards. Fecal coliform from Rio Grande City, La Joya, and Southside wastewater treatment plants exceeded permitted levels at least once in 2010 but not in 2011. E. coli levels from Rio Grande City have exceeded the NPDES permitted levels once in the last year. E. coli levels from City of La Joya WWTP have consistently exceeded limits in the past year.[293]

BOD and DO levels from City of La Joya WWTP consistently fail effluent criteria levels. Southside WWTP in Brownsville periodically has released high levels of BOD and both the plants in Brownsville and Rio Grande City experience critical DO levels leaving the wastewater treatment plants. In one case Roma released high solids concentration. Southside WWTP in Brownsville in the past has had issues with high solids concentrations but its performance has improved in the past year.[294] Solids levels from the City of La Joya WWTP have exceeded permitted levels consistently. High solids concentrations can lead to high bacteria levels as well as low oxygen levels, depending on what the solids contain, as solids can deplete the existing oxygen concentration (see Figures 4.22-4.29).

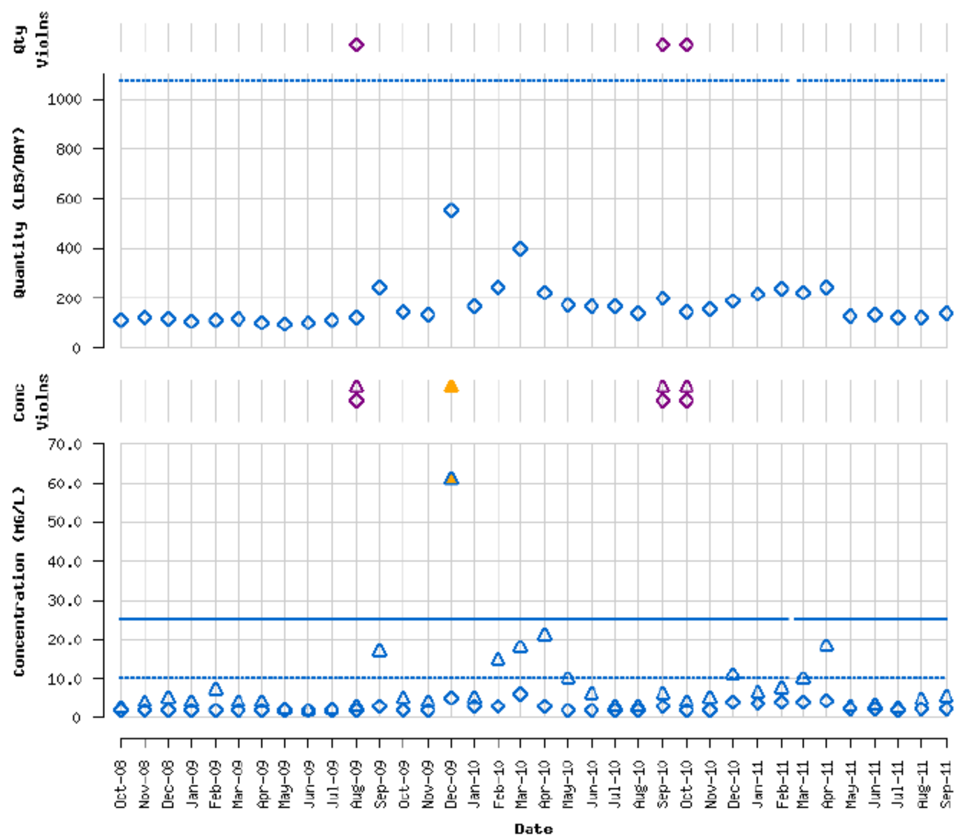
On Mexican side of the Rio Grande there are seven wastewater treatment plants located in Nuevo Laredo, Mier, Miguel Aleman, Reynosa, Río Bravo, Gustavo Diaz Ordaz, and Matamoros.[295] Information is not available to characterize Mexican treated wastewater effluent levels relative to their permitted limits.

Figure 4.22 BOD from City of La Joya WWTP



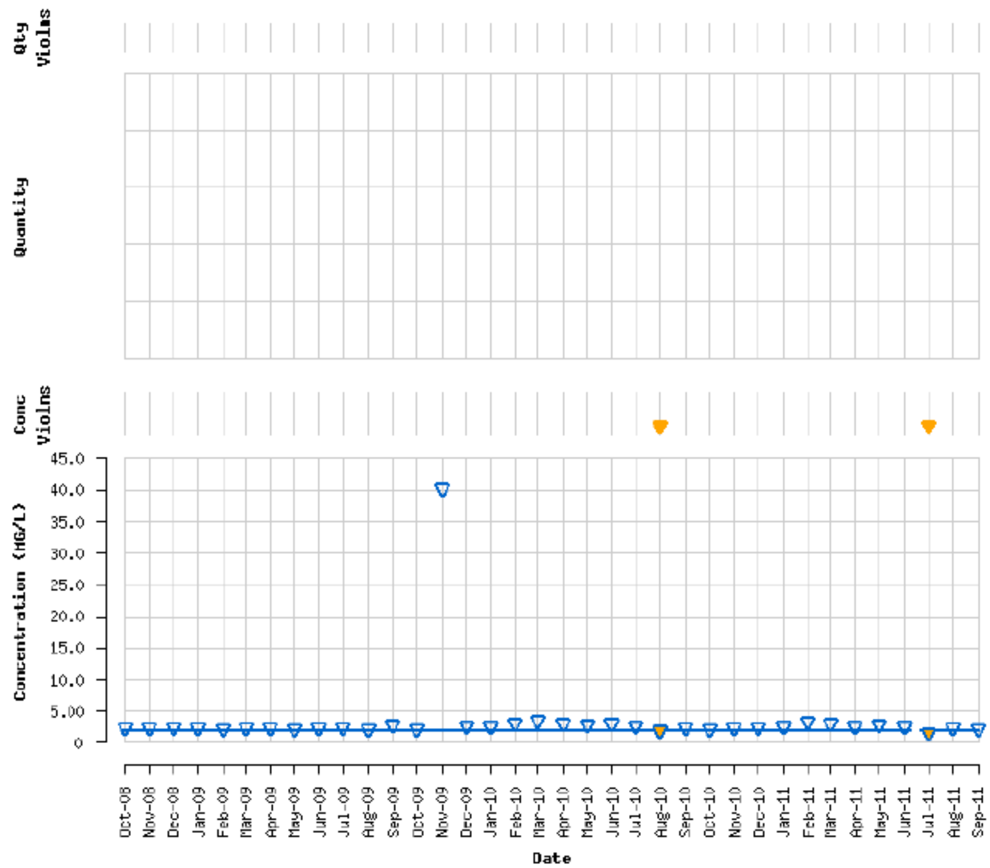
Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Figure 4.23 BOD from Southside WWTP in Brownsville, Texas



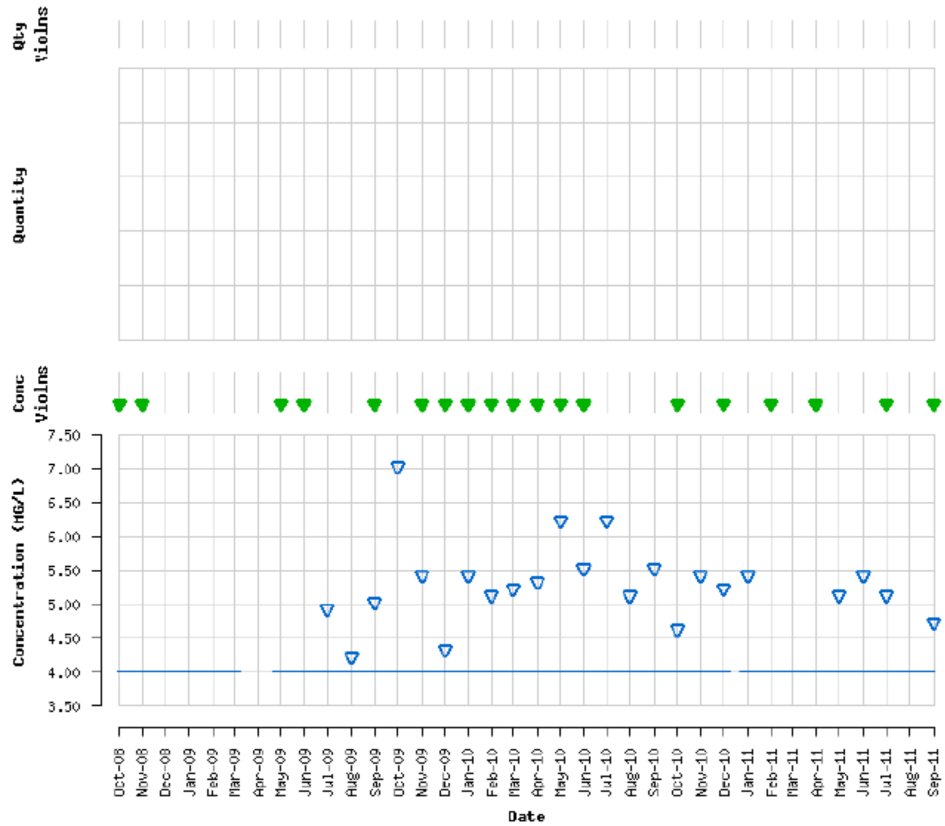
Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Figure 4.24 DO from Rio Grande City WWTP



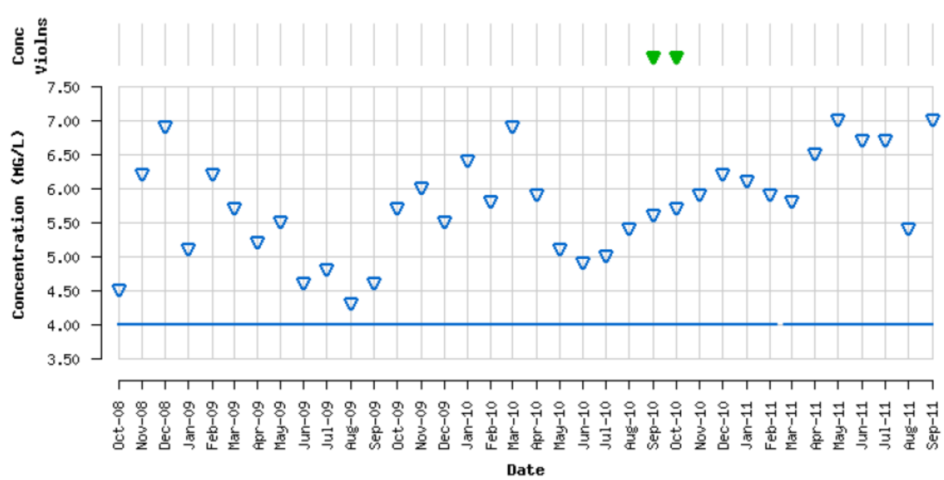
Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Figure 4.25 DO from City of La Joya WWTP



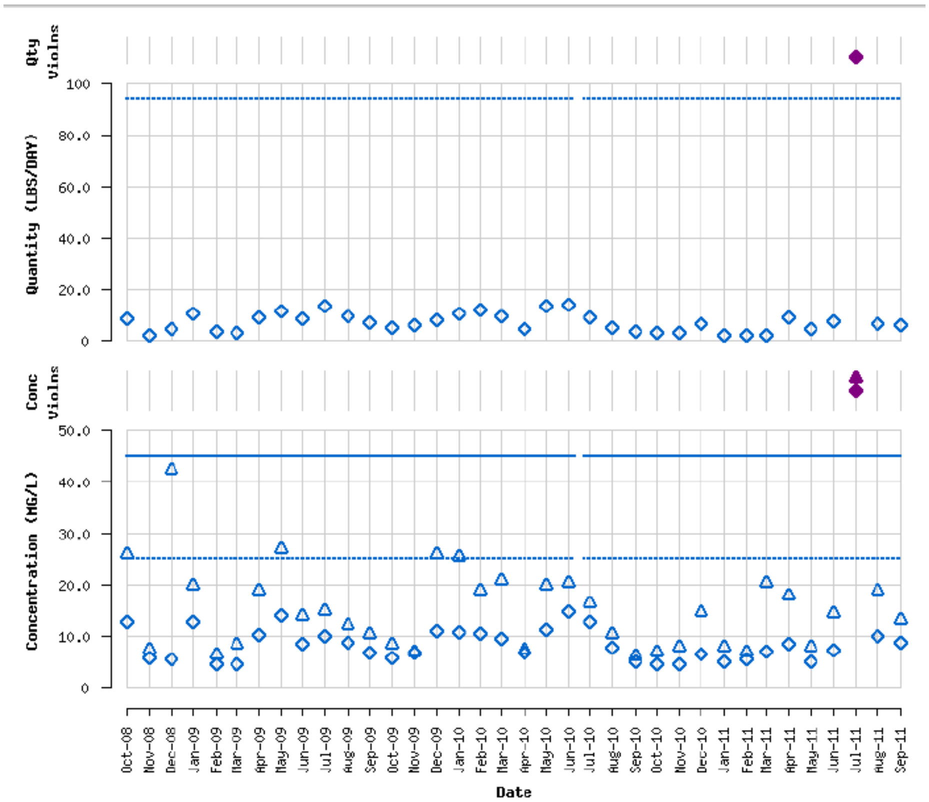
Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Figure 4.26 DO from Southside WWTP in Brownsville, Texas



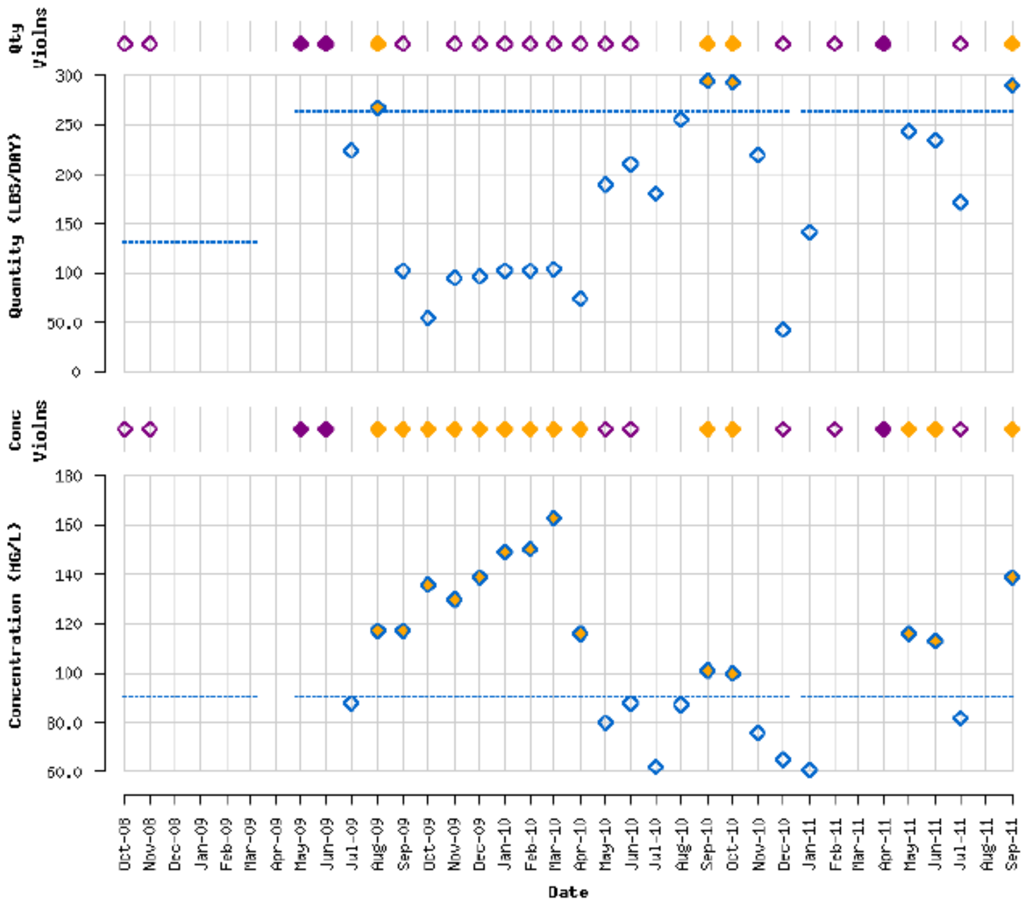
Source: EPA, “Enforcement and Compliance History Online,” available at http://www.epa-echo.gov/echo/.

Figure 4.27 Solids from City of Roma WWTP



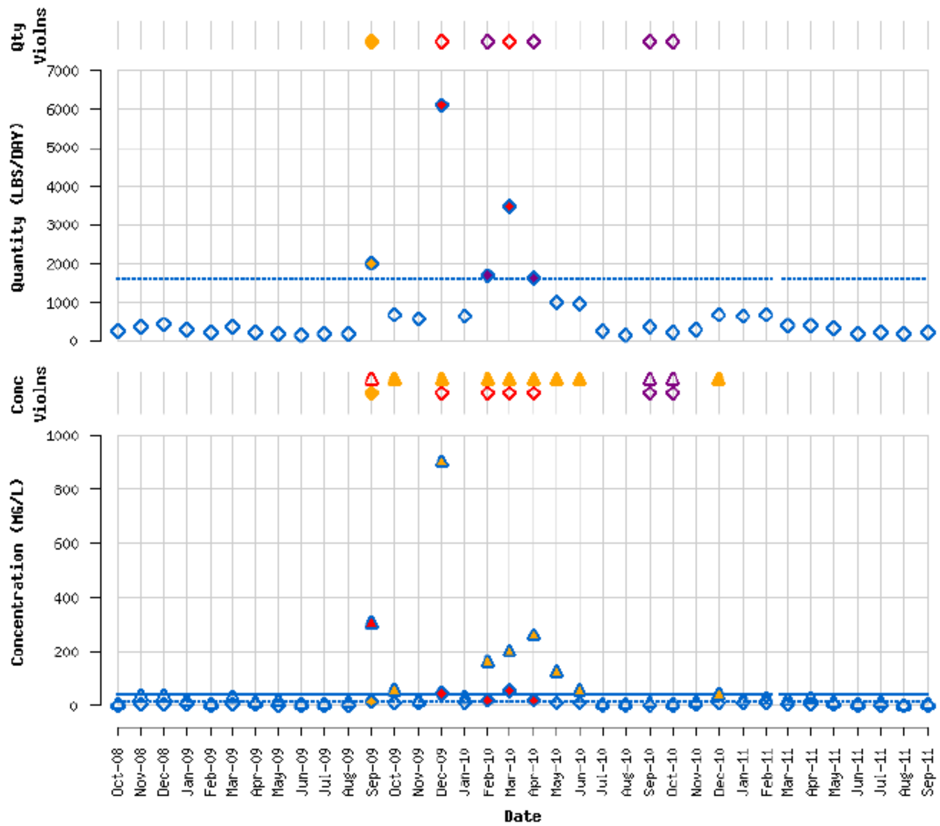
Source: EPA, “Enforcement and Compliance History Online,” available at http://www.epa-echo.gov/echo/.

Figure 4.28 Solids from City of La Joya WWTP



Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Figure 4.29 Solids from Southside WWTP in Brownsville, Texas



Source: EPA, "Enforcement and Compliance History Online," available at http://www.epa-echo.gov/echo/.

Insufficient Connection to Sewage Systems and Septic Tank Leakage

Some poor communities in both the U.S. and Mexico have no systematic method for treating wastewater. They may be disconnected from the existing sewage systems and without a septic tank or they may fail to properly maintain septic tanks. Colonias are particularly susceptible to this problem.

As reported previously, the lower Rio Grande Valley includes over a thousand unincorporated colonias, or communities that often do not possess sewer and/or wastewater treatment service. Rural populations not connected to either central wastewater or functioning regulated septic systems "can affect ground and surface water quality in several ways. Failing systems or systems improperly located can discharge inadequately treated sewage. Sewage can run off into surface waters. Sewage can contaminate water supply wells if vertical distances from ground water are insufficient.

Wastewater and sewage discharged from failing on-site systems contain bacteria and viruses that can endanger human health and harm aquatic organisms."[296]

It is likely that on-site wastewater systems, including septic tanks, are contributors to the bacteria problem in segments 2301 and 2302 of the Rio Grande/Río Bravo.[297] Many septic system problems can be prevented through more effective permit and installation programs, particularly if they can be identified through inspection before system failure.[298] Also, a properly installed septic system will not function well if it is not maintained. Septic system leakage may reflect a failure by some system owners to establish an appropriate maintenance schedule to maintain the system properly. For example, some people use organic solvents as cleaners; they may not clean the system well and can kill micro-organisms necessary for proper system operation.[299] Even with excellent maintenance, "most septic systems will fail eventually. These systems are designed to have a useful life of 20 to 30 years, under the best conditions. Eventually, the soil in the absorption field becomes clogged with organic material, making the system unusable."[300]

According to 2009 census data, 1.25 percent of septic systems in the American South had suffered a failure during the three months leading up to the census. Of those systems that had failures, 20 percent had multiple failures in those three months.[301] This means that around 5 percent of septic systems in the region experienced at least one failure over the course of a year, with many systems failing repeatedly. In 1997, the EPA reviewed septic failure rate studies across the U.S. and estimated the failure rate to be between 10 and 20 percent per year. Their data did "not include systems that might be contaminating surface or ground water, a situation that often is detectable only through site-level monitoring."[302]

A key issue on both sides of the border is the need for a septic-system inspection regime that can identify problems. On the U.S. side, the TCEQ has authorized agents in each country to inspect new septic installation and enforce the household requirement for regulated septic systems. The manner in which TCEQ agents discover septic problems in non-urban areas may reflect unanticipated events, such as when a code enforcement officer visits a household for some purpose (such as authorizing the re-connection to the electric utility) and happens to see that the septic system is not functioning properly. Complaints from neighbors may alert county authorities to a failing septic system. Starr County Judge Eloy Vera reported that his county employs two inspectors for an area larger than the state of Rhode Island. Many rural residents may not be able to replace malfunctioning septic systems without some assistance. Judge Vera indicated that incorporated municipalities have a much easier time than counties in securing a range of federal, state, or other funds to help extend sewer systems into unincorporated areas.[303]

Non-Point Sources of Pollution

Although human sewage is a primary source of bacteria in the lower Rio Grande, bacterial effluents from wildlife, domestic pets, and agricultural animals contribute to water problems. Domestic and wild animals (such as deer, beavers, rodents, and geese) can introduce micro-organisms into the water supply through direct contact or watershed runoff. Birds are a common source of contamination of open reservoirs. Tests on bacteria in some rivers have found that wildlife dung is a major source of water pollution.[304] Bacteria from improperly disposed pet waste and domesticated animals also may wash into sewers or water bodies after rain.

Agriculture is the largest single land use within the 280 mile stretch of the lower Rio Grande.[305] The most common bacteria found in the Rio Grande/Río Bravo surface waters are fecal bacteria, those naturally found in the digestive tract of warm-blooded animals, which could arise from direct deposition, storm water run-off, or confined animal feeding operations. For example, in Starr, Hidalgo and Cameron Counties, there are an estimated 117,000 cattle and 15,900 other livestock including hens and goats.[306]

Feral hogs represent a bacterial source that is much harder to confine than domesticated livestock. As of 2011, there are currently over 1.5 million feral hogs in Texas that "tend to congregate around water sources to drink and wallow. This concentration of high numbers in small riparian areas poses a threat to water quality, as fecal matter deposited directly in streams by feral hogs contributes to bacteria and nutrients."[307,308] Although "data on biology and population characteristics of feral hogs in Texas are very scarce,"[309] it is clear that hogs contribute to water quality problems such as high bacteria loadings. They are "considered free-ranging livestock. Feral hogs and their damage are the responsibility of the landowner where they are found."[310] Neither Mexican nor Texan governments possess a right to go on private land to confront the feral hog population, so landowners, who may or may not know the most effective or cost-effective ways of decreasing feral hog populations on their land, may have to shoulder the burden of cost and effort.

Endnotes

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Chapter 5. Local Stakeholders' Perceptions of Water Quality in the Lower Rio Grande/Río Bravo Basin

Both the governments of Mexico and the United States have advocated for many years to improve the ambient water quality within the Rio Grande/Río Bravo. Because the Rio Grande/Río Bravo constitutes an international boundary separating two sovereign nations, improvements in water and wastewater treatment face challenges unique to trans-boundary water sources. Federal, state, and local governments in both Mexico and the U.S. have sought to understand the water quality preferences and perceptions of residents along the Rio Grande/Río Bravo. For example, do residents believe that the river is clean enough for swimming, fishing, or boating? How polluted is the Rio Grande/Río Bravo and do residents care about its quality? Who ought to be responsible for cleaning it up? Answers to these and other water quality questions will inform policy makers as they cooperate to meet their citizens' needs for a clean and healthy environment.

The Lower Rio Grande Water Quality Initiative (LRGWQI) examined residents' opinions through surveys distributed to American stakeholders in 2012 and plans are being made to distribute surveys to Mexican stakeholders in 2013. This report examines the survey responses of local residents on the U.S. side of the Rio Grande/Río Bravo as well as managers of organizations concerned with water quality. Future reports will integrate the results from Mexican stakeholders, allowing policymakers to identify common views among U.S. and Mexican citizens across the river.

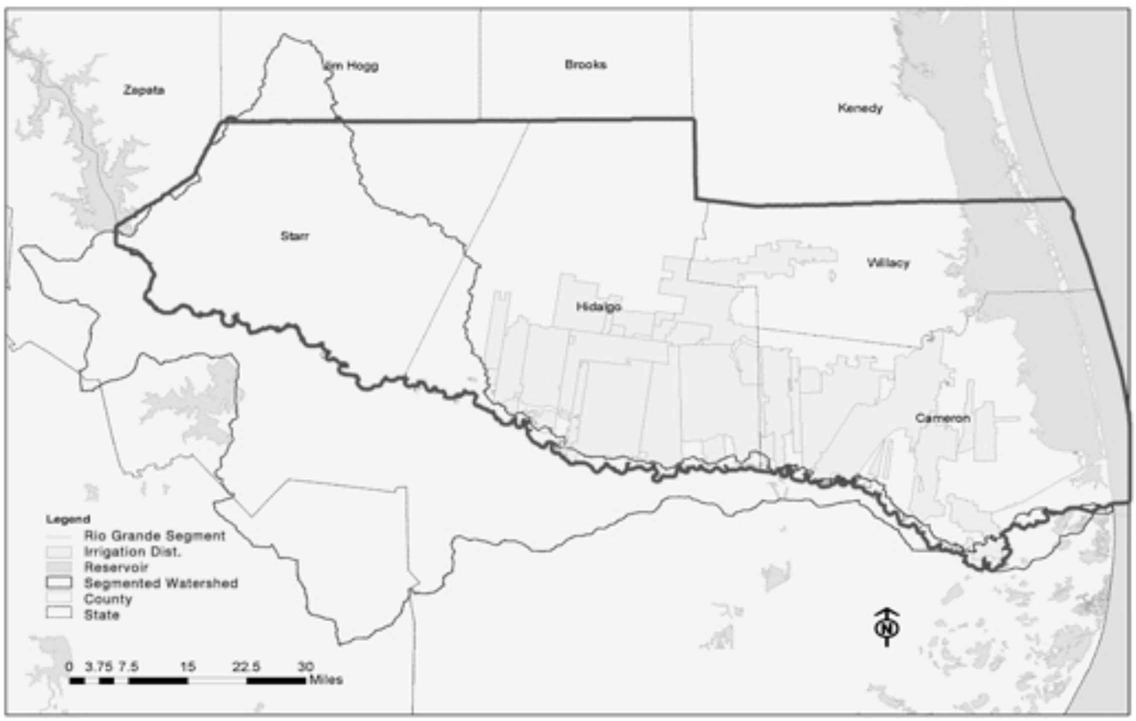
The initial surveys targeted residents living in four U.S. counties along the lower Rio Grande/Río Bravo: Cameron, Hidalgo, Starr, and Willacy. The primary purpose was to gather information that will help policy-makers understand local attitudes about water quality in the Lower Rio Grande/Río Bravo Basin. The first survey goal was to ask about residents' attitudes regarding water quality. This included stakeholder's preference for a clean river, reports of the level of current pollution, major sources of pollution, and any negative impacts of pollution on residents' lives. Questions 1 through 7 addressed this objective. The second goal was to solicit information on what action could decrease pollution and who should be responsible for leading that process. Residents understand the political and social environment in which their community operates and can provide insight into solutions for which there is support. These suggestions may form the basis for future water quality improvement programs. Questions 8 and 10 solicit these suggestions.

A third goal explored the willingness of residents to invest in solutions to reduce effluent discharge to the river. Question 11 asked for the value of resident's current water bill. Question 12 asked how much extra residents would be willing to pay each month to make sure the Rio Grande is clean enough to swim in. A fourth goal was to inquire where residents receive information on water quality. Question 9 explicitly asked this question. The results indicate effective communication tools for educational programs and water quality improvement projects. The final eight survey questions gathered demographic information in order to explore comparisons across various populations segments. Appendix A includes a copy of the distributed survey in English and Spanish.

Methodology

To reflect the residents of the region, the LRGWQI chose to administer the water quality survey to three population samples: (a) a random sample of residents; (b) a targeted sample of residents; and (c) leaders of organizations involved with water quality. The entire geographic areas of Cameron, Hidalgo, Starr, and Willacy counties (with minimal gaps) were included in the U.S.-based population of the Lower Rio Grande Valley, as those populations either withdraw water from the river or discharge water to the river. The black outline in Figure 5.1 shows the four counties that were targeted.

Figure 5.1 Target Area for Lower Rio Grande Survey Respondents on the U.S. Side



Source: Derived from an unpublished GIS shapefile from TCEQ, Irrigation districts from Texas A&M AgriLife Extension Service, Map created by Roger Miranda for the Lower Rio Grande Water Quality Initiative, 2012.

Inhabitants within the watershed in Starr County and in the highlighted Irrigation Districts in Willacy, Hidalgo, and Cameron counties formed the population of water users. The population of water users is not synonymous with the persons who live within the physical boundaries of the watershed. Given the small portion of Jim Hogg County that is included in the watershed and/or associated with water use and wastewater discharges to the Lower Rio Grande, the LRGWQI made a decision not to include its residents in this survey. Customers of water suppliers or waste water service providers in the region can be identified in part by the population whose services are provided by utilities that hold certificates of Convenience and Necessity (CCNs).

English and Spanish versions of the 20-question survey were administered to accommodate the language preferences of respondents (see Appendix A for copies of the survey in English and Spanish). The LRGWQI distributed the survey to the three stakeholder groups via mail and in-person though site-administered field surveys, a random-sample mail survey, and a mail survey to responsible officials of water quality organizations. Survey respondents were informed that the goal of the survey was to gather information about water quality in their area to understand local attitudes about water quality in the Rio Grande.

LRGWQI team members conducted the site-administered field survey on the weekend of March 2, to March 4, 2011. A team of four students traveled to the Rio Grande Valley to survey local residents on their opinions and preferences for water quality in the Rio Grande. The team visited five locations in the Valley: Nuestra Clinica del Valle in Pharr Texas; a colonia meeting in San Juan, Texas; a farmers' market in Brownsville, Texas; a street market in Harlingen, Texas; and a Red Cross event in Harlingen, Texas. At the clinic in Pharr, the research team surveyed patients who were waiting in the main lobby, almost all of whom responded to the Spanish-language survey. Many of the Pharr respondents had lower incomes than participants surveyed later in the weekend. In San Juan, Texas, the team attended a colonia self-help meeting at La Union del Pueblo Entero (LUPE). Many of the attendees surveyed were colonia residents. In Brownsville, the team surveyed vendors and shoppers at a farmers' market. The farmers' market population had attained higher levels of education and had higher incomes than those in Pharr and San Juan. In Harlingen, Texas, the researchers surveyed participants at a farmers' market/street market and a celebration put on the Southern Texas Chapter of the Red Cross. The Harlingen samples reflected a wide range of education and income levels.

The random-sample mail survey was mailed to a sample of 1,000 residents of Starr, Willacy, Cameron, and Hidalgo counties, based on a pseudo-random sample generated by Survey Sampling International (SSI) on December 6, 2011, from the U.S. Postal Service's Delivery Sequence File, which covers about 95 percent of households in the four-county area. Of the 1,000 addresses, approximately 788 included names. For the remaining 218, the term "current resident" was used as an addressee. To enhance the response rate, two postcards were mailed to the respondents in addition to the survey itself. The first postcard asked respondents to participate in a forthcoming survey; it was mailed February 17, 2012. The survey itself was mailed on March 6, 2012. A follow-up postcard was mailed on March 27, 2012, reminding respondents to complete their survey. As of October 25, 2012, 80 mailed responses had been received, for a response rate of approximately 8 percent, a substantive response rate for a mailed survey of this kind.

The survey was also distributed to leaders of U.S. organizations located within the target counties involved with water quality. Organizations included local government, utilities, wastewater treatment facilities, irrigation districts, academic institutions, colonias, and nonprofit organizations. The survey was distributed to these individuals via mail November 6, 2012.

Survey responses from all three sources were coded and imported into the Statistical Packaging for the Social Sciences (SPSS) software for detailed data analysis. In order to group similar responses, all open questions were reviewed and standardized into categories. The original text answers were recorded and stored to supplement and verify this coding. Descriptive analysis of all 20 questions and cross-tabulations among certain questions were conducted. Chi-square tests were also produced to test the independence among answers to questions and demographic attributes (see Appendix C).

Results

This report presents the collected survey data in three categories: demographic attributions of the sample; respondents' attitudes towards water quality; and respondents' attitudes towards pollution in the Rio Grande/Río Bravo. Overall, responses show that U.S. stakeholders believe a clean Rio Grande/Río Bravo is important, are concerned over current levels of pollution, and indicate a willingness to invest in solutions to improve water quality. Further cross-tab analysis demonstrates that these beliefs are independent of demographic attributes.

According to the demographic information elicited by questions 13 through 20, median monthly family income reported for the sample is slightly higher than $2,500, which translates to about $30,000 per year. This is comparable with 2010 Census data, which show median yearly family income ranging from $22,418 in Starr County to $30,769 in Cameron County.[311] Nearly 69 percent of respondents identified themselves as Latino or Latina, compared to 87 to 95 percent classified as Hispanic by the Census.[312] There is discrepancy between the median age of respondents (50 years) and the median age of residents (29-32 years), as the typical person who answered survey questions was often a head of household or other adult respondent who had spent, on average, 14 years in their current homes, indicating long-term residence. Table 5.1 summarizes these results. Appendix A lists distributions of the demographic attributes of survey respondents.

Table 5.1 Demographic Attributes of Survey Respondents

Survey Question	Survey Response
What year were you born?	Max Age: 88, Min Age: 19, Median Age: 50
Were you born in Starr, Willacy, Cameron, or Hidalgo county?	Yes: 39.8% No: 60.2%
What is your gender?	Male: 48% Female: 51%
Do you consider yourself Latino or Latina?	Yes: 68.9% No: 31.1%
What is your highest education level?	High school or below: 29.7% Some college or above: 70.2%

How many years have you lived in your current home?	Mean: 14.7 years
What is the monthly household income of your family?	Median: approximately $30,000 per year
Do you or someone in your family own your home or is the home rented?	Own: 82.2% Rent: 17.8%

Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Respondents' Attitudes Towards Water Quality

Questions 1 through 4 asked for respondents' attitudes towards water quality in the Rio Grande/Río Bravo (Table 5.2 summarizes the results). The result shows that a majority of the sample population, across all demographic groups, believe that the water quality of the Rio Grande/Río Bravo is important. Supplemental questions helped to further reveal respondents' attitudes towards water quality.

Table 5.2 Respondents' Attitudes Towards Pollution in the Rio Grande/Río Bravo

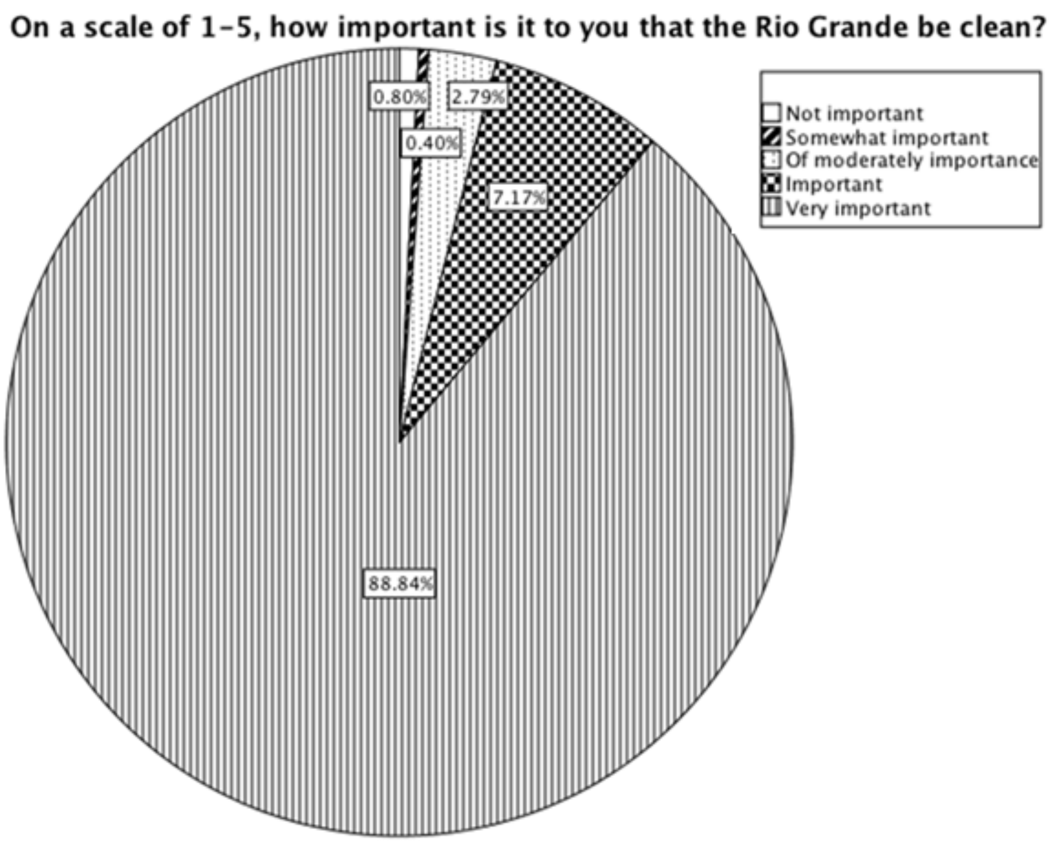
Survey Question	Survey Response
On a scale of 1(not polluted) to 5(very polluted), how polluted is the Rio Grande in your opinion?	Very polluted: 31.2% Polluted or Very Polluted: 64.8% Somewhat polluted or more: 92%
What do you think is the biggest source of pollution in the Rio Grande?	Trash/litter: 41% Sewage: 23% Mexico: 18.4% Industrial: 15.2%
How do you think pollution in the Rio Grande affects someone like you?	Health: 48.1% Recreation: 12.4% Environment: 12%
Who do you think should be responsible for making sure the Rio Grande is clean?	Everyone: 28.7% US and Mexico: 21.5% State: 19.4%
Where do you get information about water quality in the Rio Grande? TV, Radio, Newspaper, Internet, Friends/Family, Personal Experience, Other	TV: 56.2% Newspaper: 44.2% Internet: 30.6% Radio: 22.7%
What do you think should be done to improve water quality in the Rio Grande?	Legislative/government enforcement: 32.3% General clean-up: 20.2% Technological Improvements: 15.7% Improve education: 12.5%

About how much is your water bill each month?	Max: $917.0, Min: $0, Mean: $83
How much extra would you be willing to pay each month to make sure the Rio Grande is clean enough to swim in?	70% are willing to pay, Max: $100, Min: $10, Mean: $12 for those willing to pay

Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

The majority of survey participants (88.8 percent) responded that they considered "very important" that the Rio Grande be clean and 96 percent responded that it is either "important" or "very important" (see Figure 5.2).

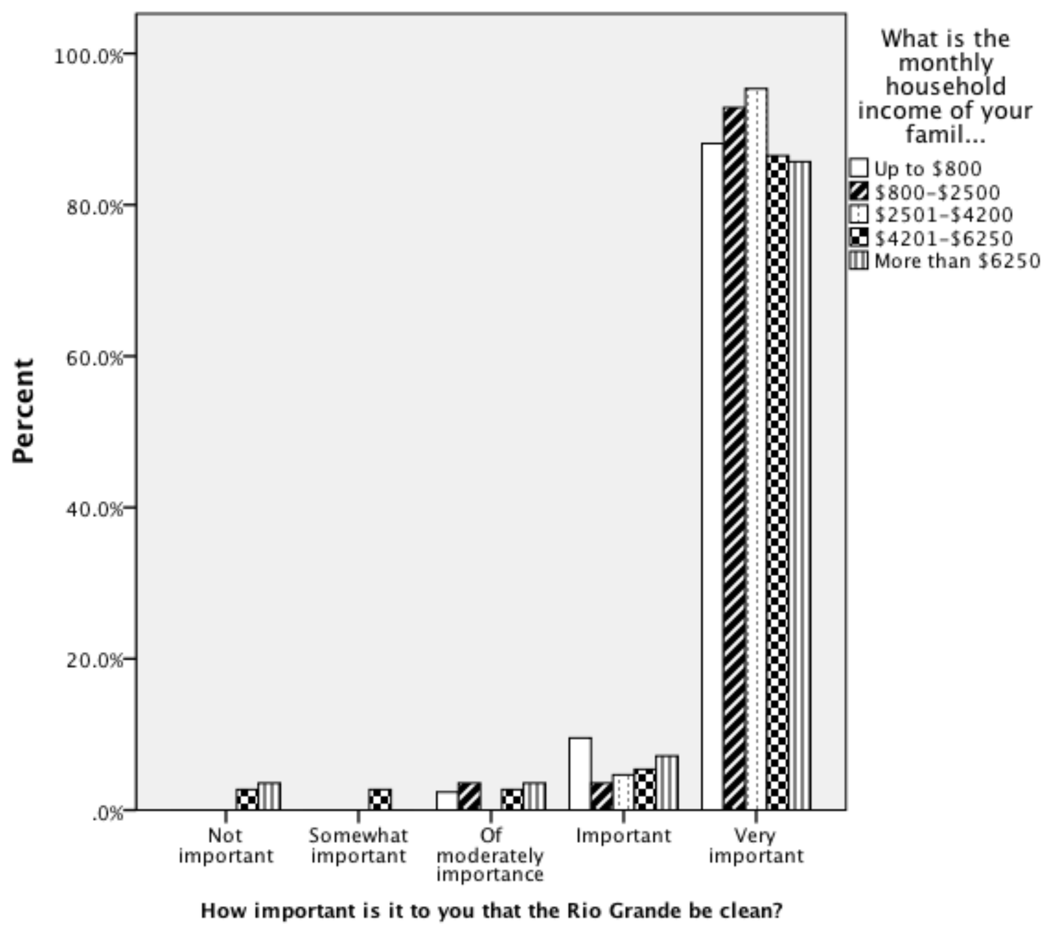
Figure 5.2 Importance of Water Quality



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012

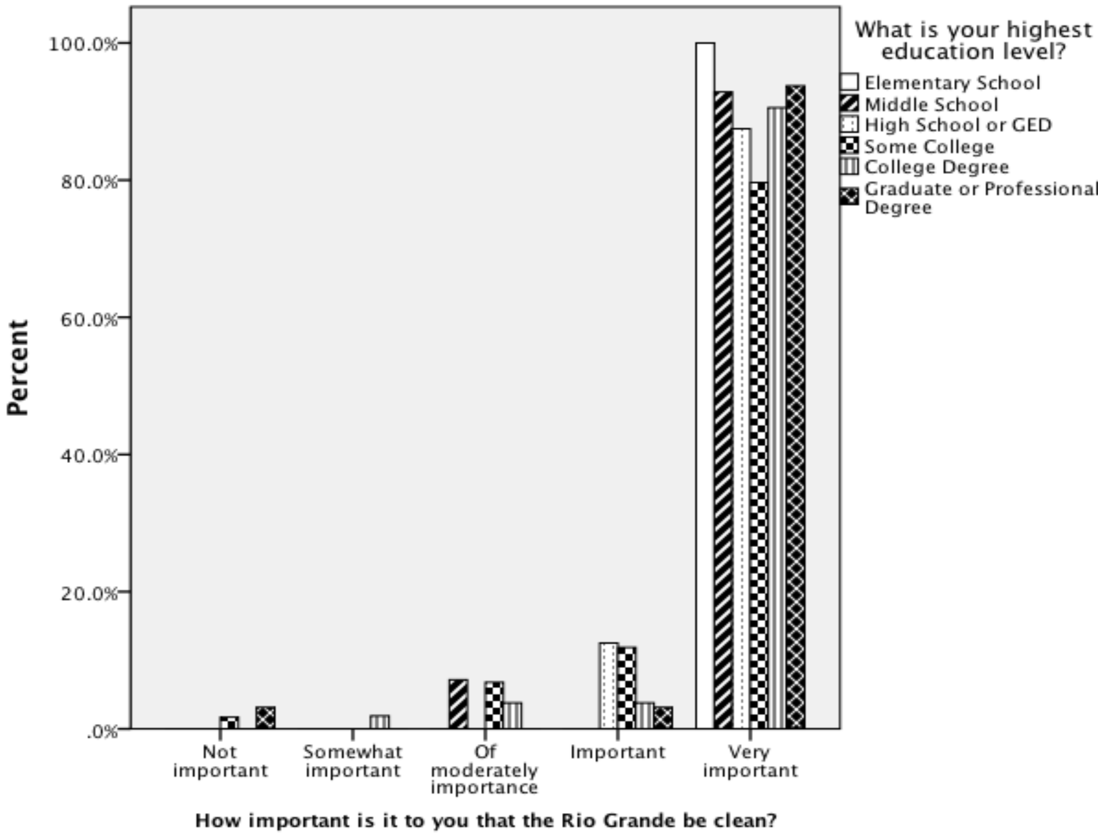
Preferences for water quality do not vary much with demographic attributes, such as income, education level, or years lived in the area (see Figures 5.3, 5.4, and 5.5). Chi-square tests also support that water quality preference is independent of demographic attributes. Although not statistically significant, a slightly larger proportion of respondents with lower education attainment levels indicate a stronger belief in keeping the river clean. All (100 percent) respondents who have lived in their current home for over 35 years picked the "very important" option.

Figure 5.3 Monthly Income and Rio Grande/Río Bravo Water Quality



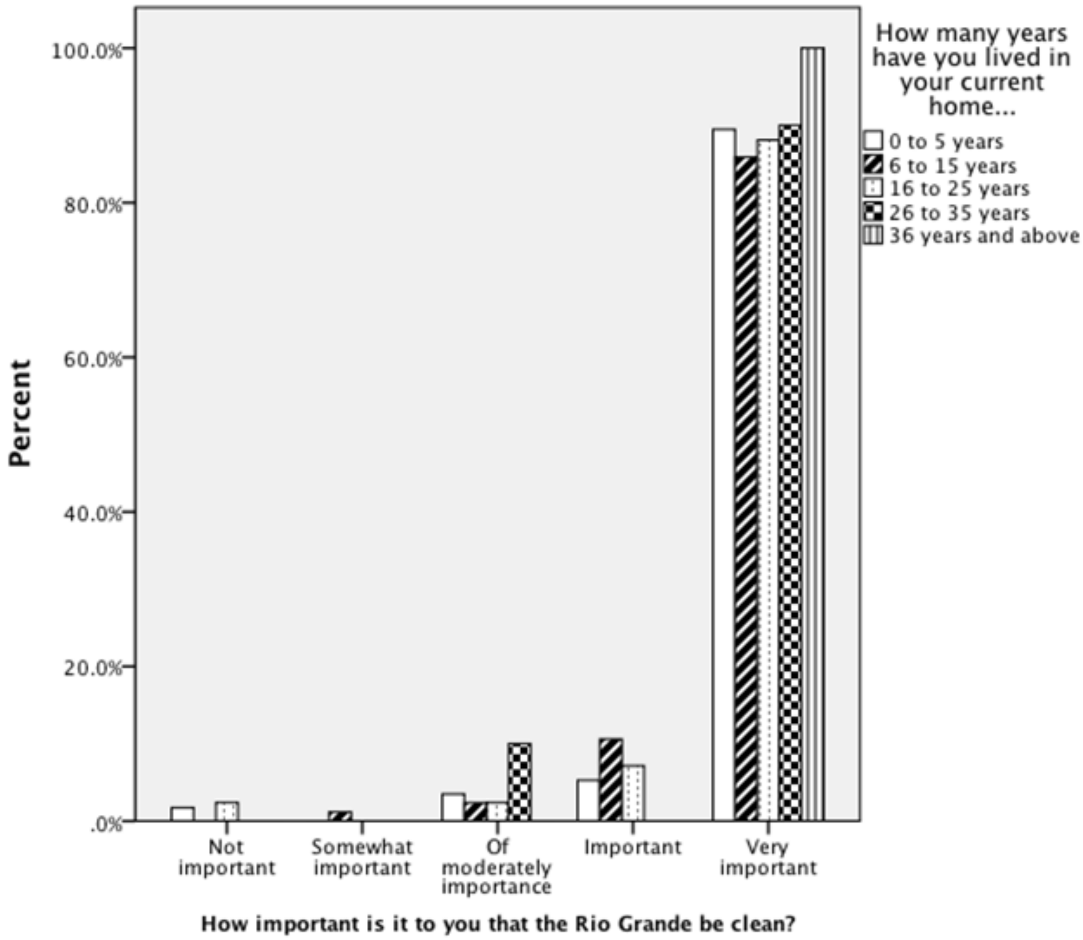
Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Figure 5.4 Education Level and Rio Grande/Río Bravo Water Quality



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

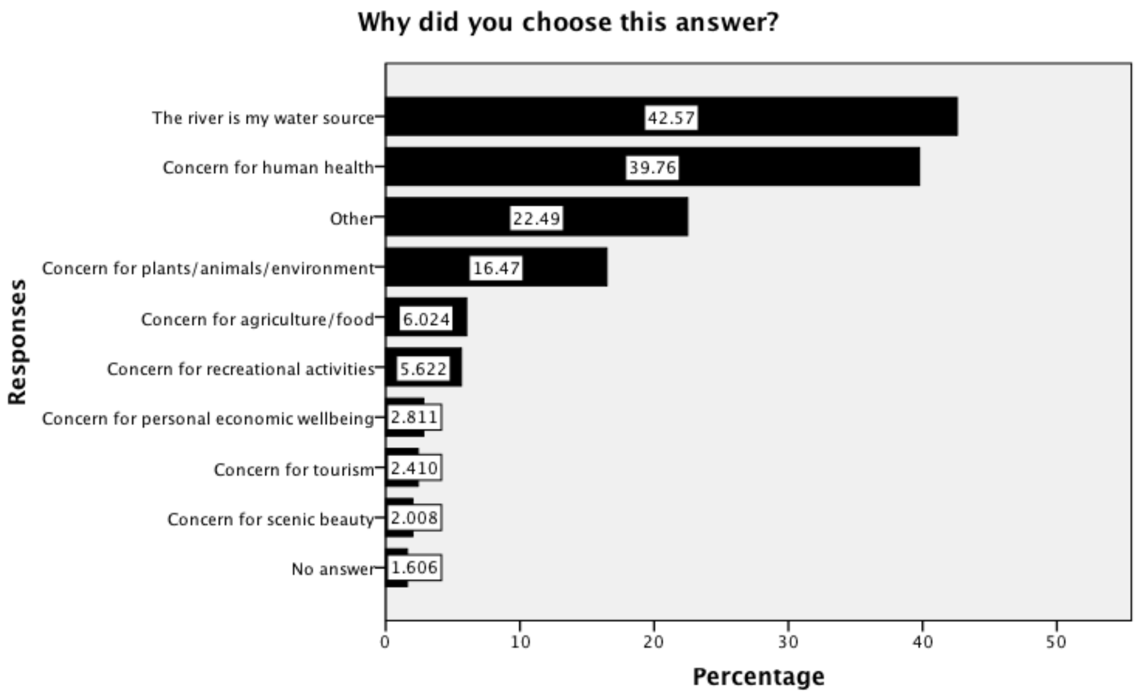
Figure 5.5 Residence and Rio Grande/Río Bravo Water Quality



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Respondents indicated diverse reasons for the importance of water quality. Forty-three percent responded that the river is their water source, mainly for drinking and cleaning. About 40 percent mentioned water quality concerns for human health from drinking or cleaning with polluted water or eating food irrigated by polluted water. An additional 16.5 percent reported a concern for plants/animals and the environment (see Figure 5.6). Among "concern for human health" answers, several respondents mentioned "health of children" as a concern.

Figure 5.6 Why is Water Quality Important to You?



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

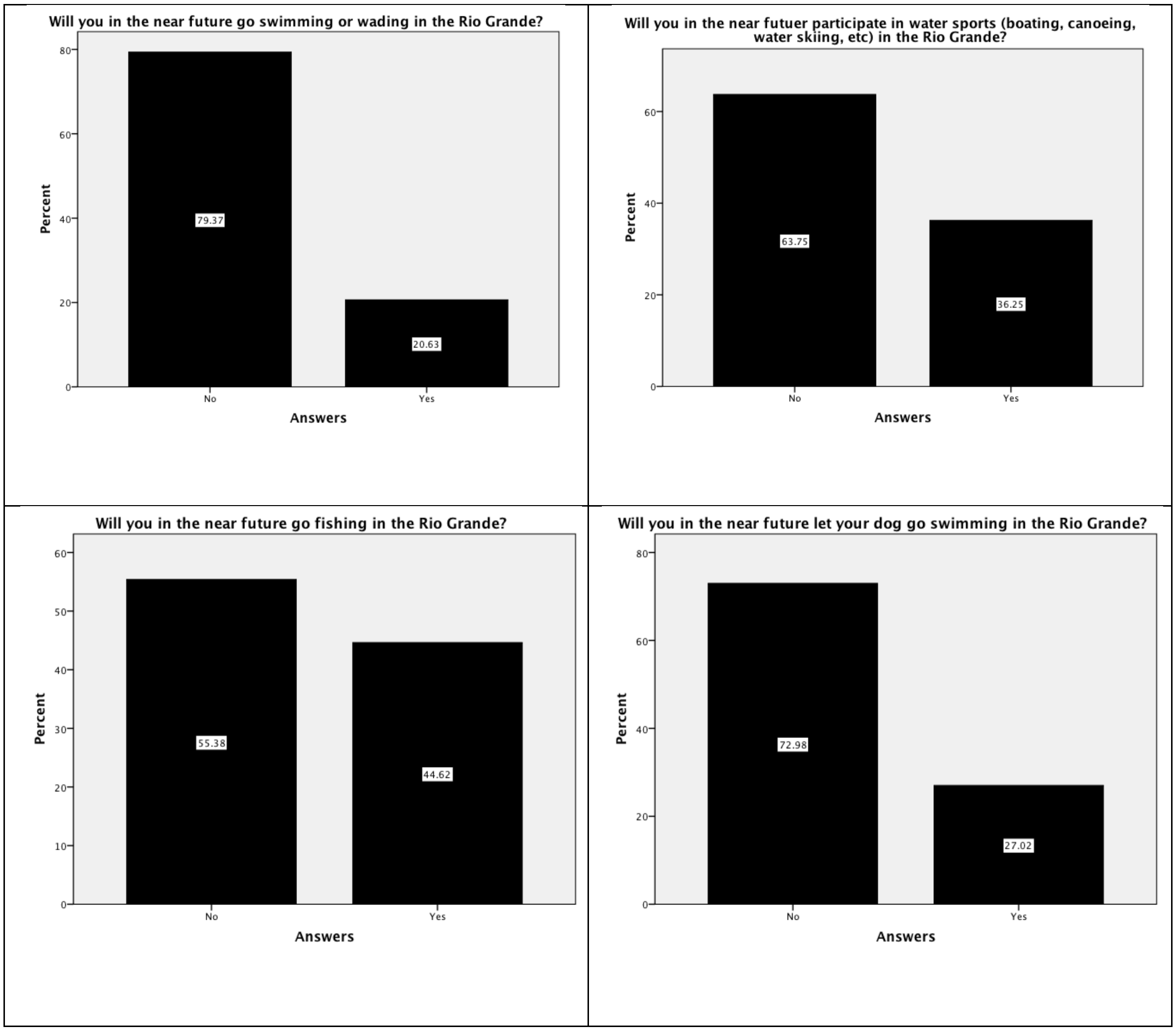
When asked about whether they expect to participate in recreation activities in the Rio Grande/Río Bravo, a majority of responses reveal they are not willing now to participate in river recreation. Indeed, 55.4 percent to 79.4 percent indicated they will not go swimming, fishing, or participate in water sports in the near future. On the other hand, nearly all respondents (86.8 percent) reported that it is important that people are able to swim, fish, or recreate in the river (see Figures 5.7 and 5.8).

Pollution in the Rio Grande/Río Bravo

Questions 5 through 12 asked for residents' attitudes towards pollution levels in the Rio Grande/Río Bravo (see Table 5.2). Almost all residents (98 percent) perceive the Rio Grande/Río Bravo as polluted at some level, with 31.2 percent reporting it is "very polluted" (see Figure 5.9).

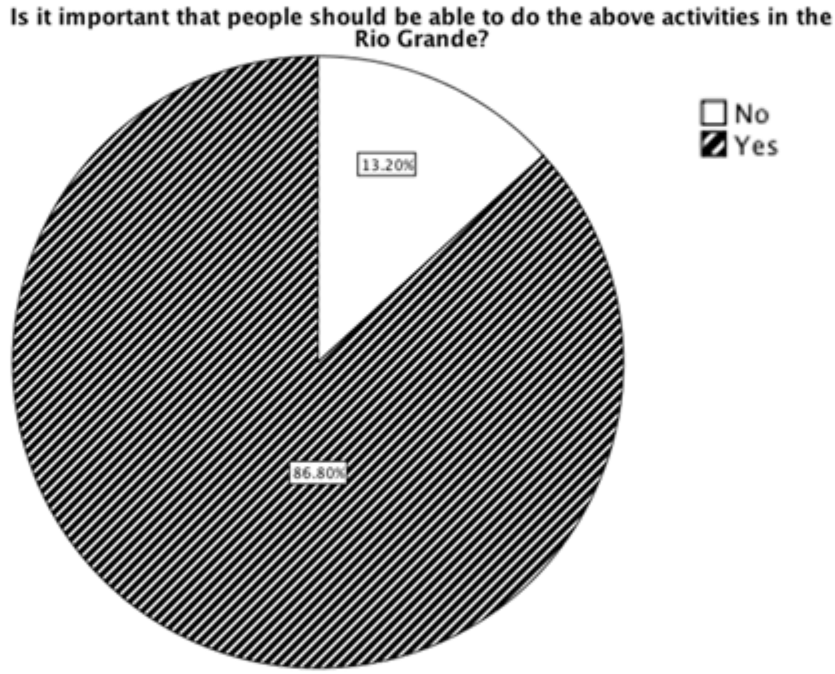
Cross tabulation suggests that respondents who were older, considered themselves Latino/a, or lived in the area longer than 15 years were more likely to choose "polluted" or "very polluted" to describe the river's ambient water quality. A slightly higher proportion of respondents at the lowest education level (see Figure 5.10) report that the river is "very polluted," although educational attainment was not a significant explanatory variable. Other demographic attributes were not correlated with respondents' answers.

Figure 5.7 Respondent's Willingness to Participate in Water Activities



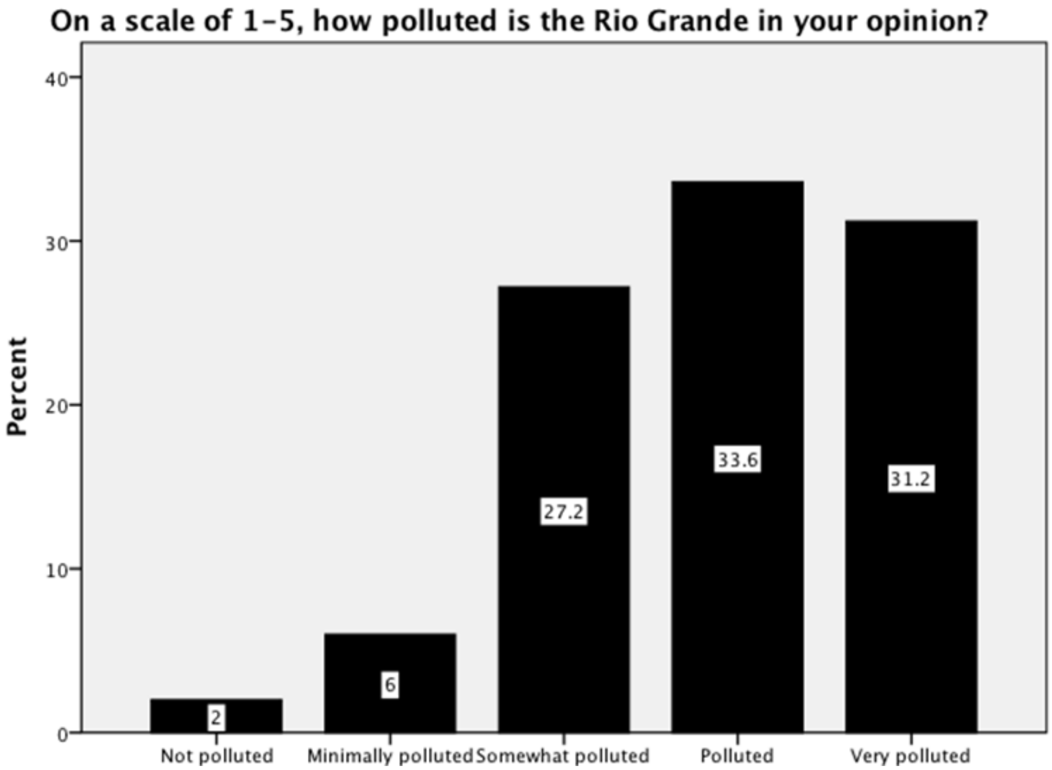
Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Figure 5.8 Respondents' Interest in Participating in Water Activities



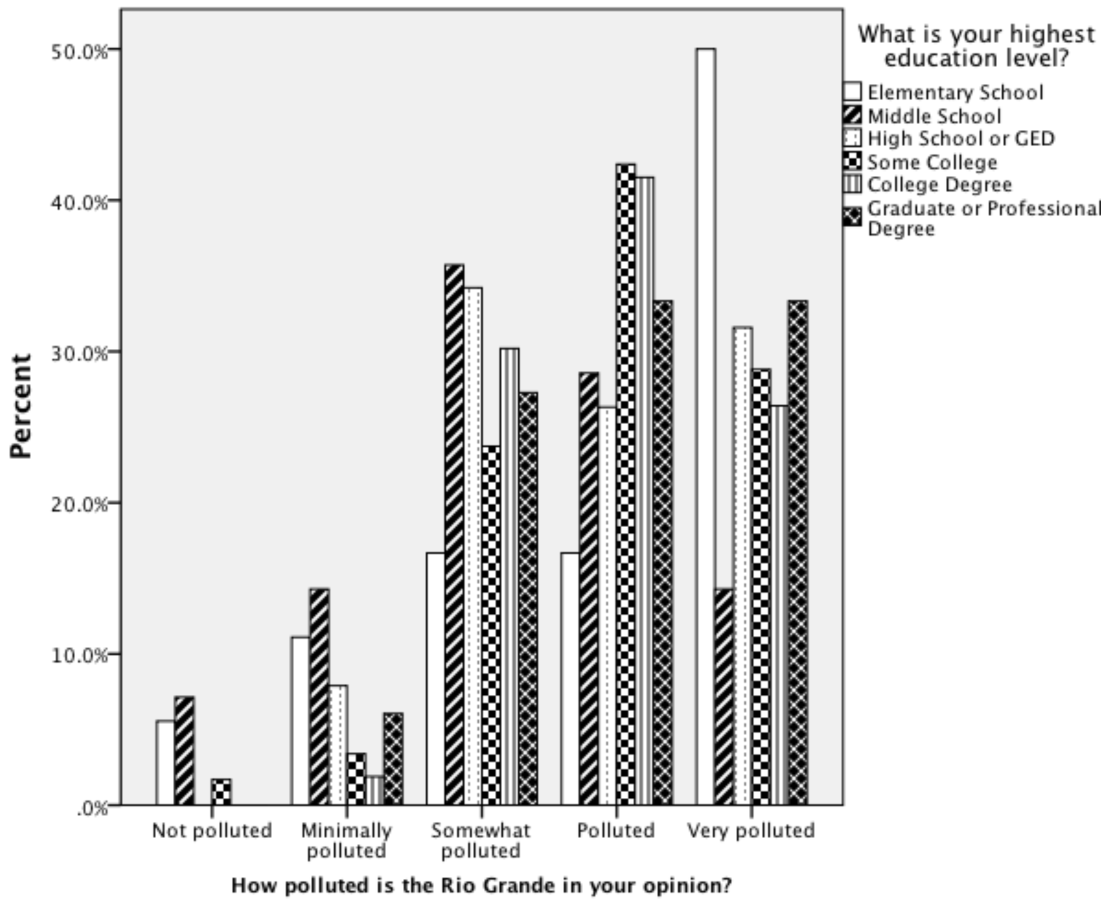
Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Figure 5.9 Respondents' Perceptions of Pollution in the Rio Grande/Río Bravo



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Figure 5.10 Education Level and Level of Pollution in the Rio Grande/Río Bravo



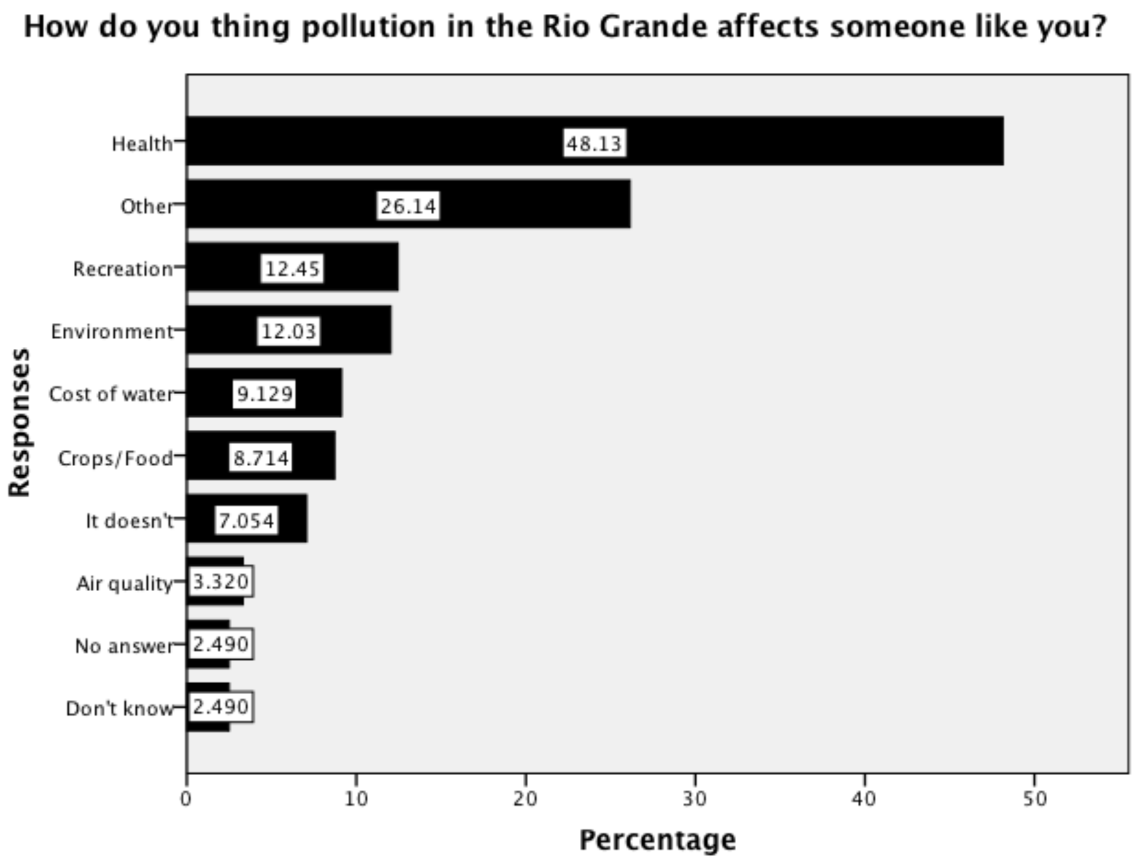
Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Concern for human health resurfaces when respondents are asked how pollution affects their lives (see Figure 5.11). A total of 48.1 percent associate damage to their health as a main effect of water pollution. This concern surfaced across all demographics. Among the "concern for human health" responses, several health problems were mentioned, including "causes infections," "mosquito problems," "allergies," "skin disease," and "problems in the lungs." One respondent attributed autism among children to a bad drinking water source. Several respondents stated that due to poor water quality they have to buy bottled water, which is expensive. An elderly resident reported that she "can't afford to get ill." One of eight respondents (12.4 percent) noted that pollution limits their recreation activities in the river.

Chi-square analysis suggests a relationship exists between education level attained and propensity to believe that pollution levels negatively affect recreation opportunities on the river, as 16.5 percent of respondents who have some level of college education or above identified limited recreation activities as compared to only 2.8 percent of respondents with lower education levels. Gender and the means by which the survey was distributed may affect opinions about pollution on cost of water, with 12.8 percent of males and only 6 percent of females expressing concern. Also, 20.8 percent of experts and 16.4 percent of respondents' sampled in person indicated concern over higher cost of water, as compared to only 5 percent of mailed survey respondents.

In addition to health, recreation, and cost of water, 12 percent of respondents' perceived pollution as damaging to the environment and 8.3 percent feared effects on crops and food.

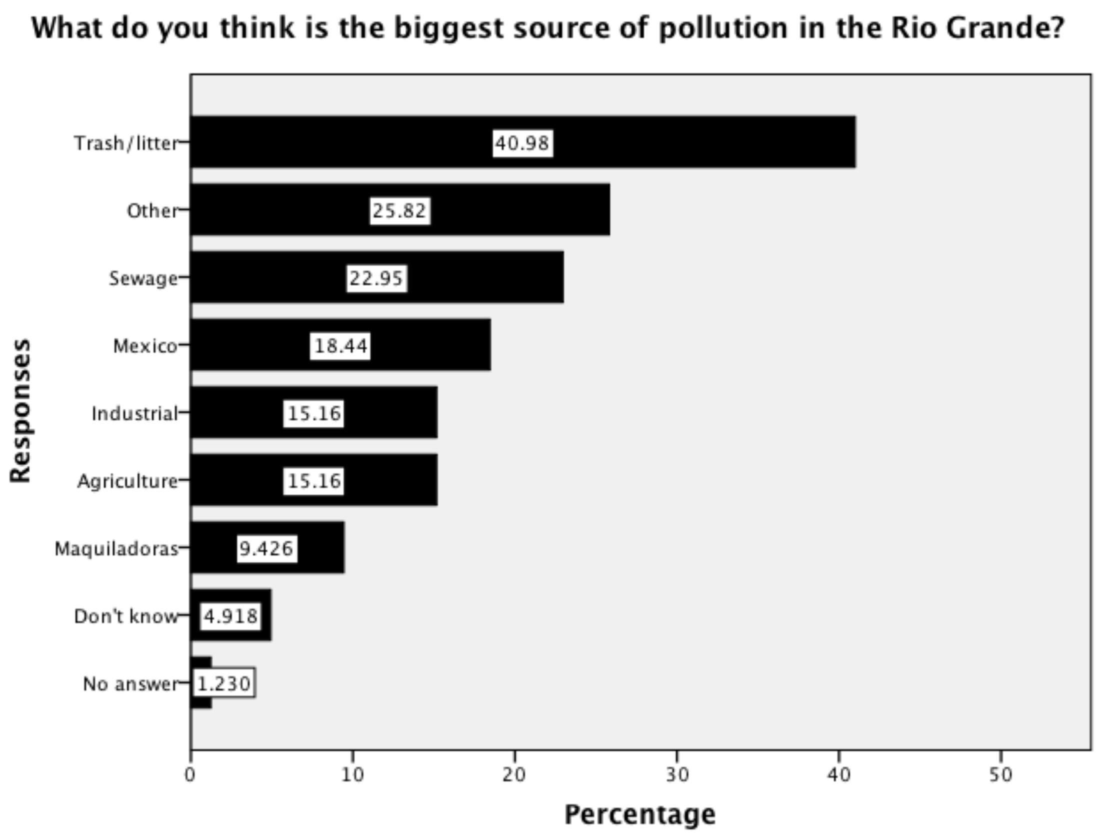
Figure 5.11 Respondents' Answers to the Effects of Water Pollution



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Responses to the question “what is the biggest source of pollution” were coded into broad categories. The most frequently mentioned were “trash and litter,” “sewage,” “industrial,” “Mexico,” and “agriculture” (Figure 5.12). Respondents also mentioned “people don’t know about water preservation,” “lack of regulation in Mexican side,” “pollution run off from both U.S. and Mexico” and other answers. The largest group of answers point to “trash and litter” as main pollutants (41 percent), and 23 percent mention “sewage”. Another 18.4 percent point out “Mexico” as a source and 15.2 percent mention “industrial” sources.

Figure 5.12 Pollution Sources in the Rio Grande/Río Bravo

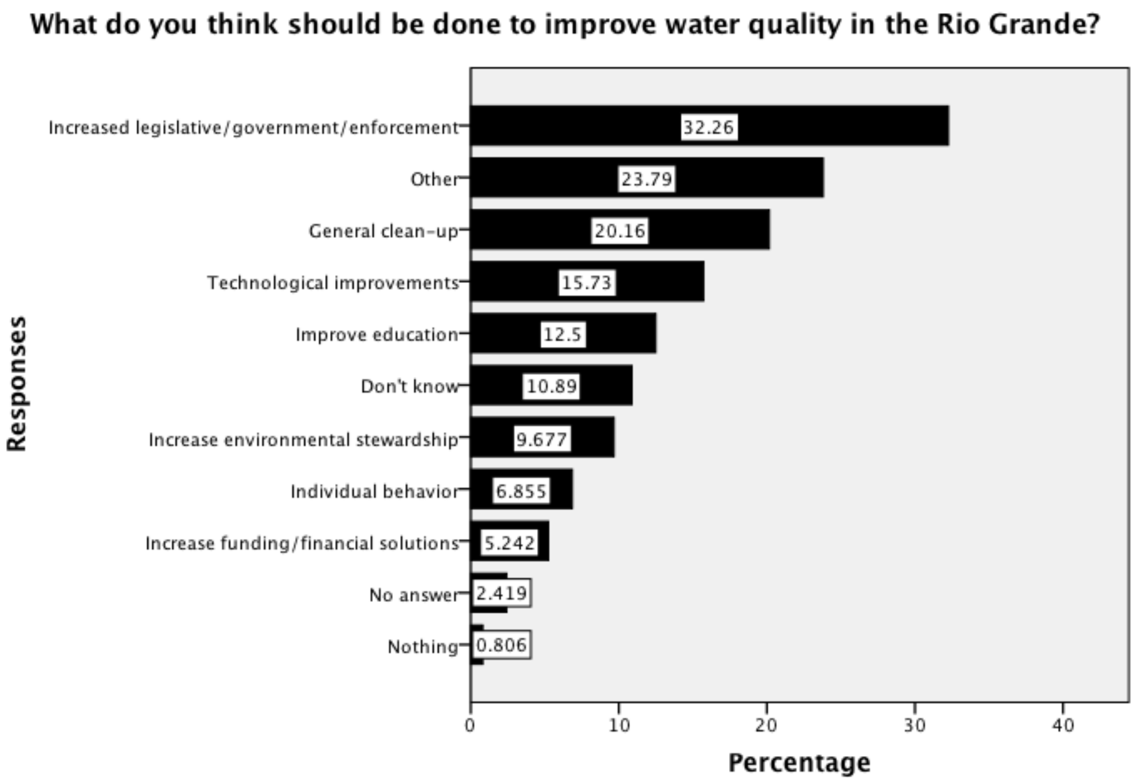


Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Concerning possible solutions to improve water quality (see Figure 5.13), support for water quality legislation or government enforcement was most cited (32.3 percent).

Outside of government enforcement, another 20.2 percent of respondents recommend a general clean-up of the river. This is followed by technological innovations or investments (15.7 percent), suggestions for increased education (12.5 percent) and improving environmental stewardship (9.7 percent). More specific suggestions indicated "enforce regulations, especially sewage and chemicals," "education, especially geared towards kids," "more retaining ponds to filter water," "more monitoring to prevent pollution, like people throwing trash," "unite communities to clean the river," and "border states need to get together and work together, help Mexico manage waste load into river."

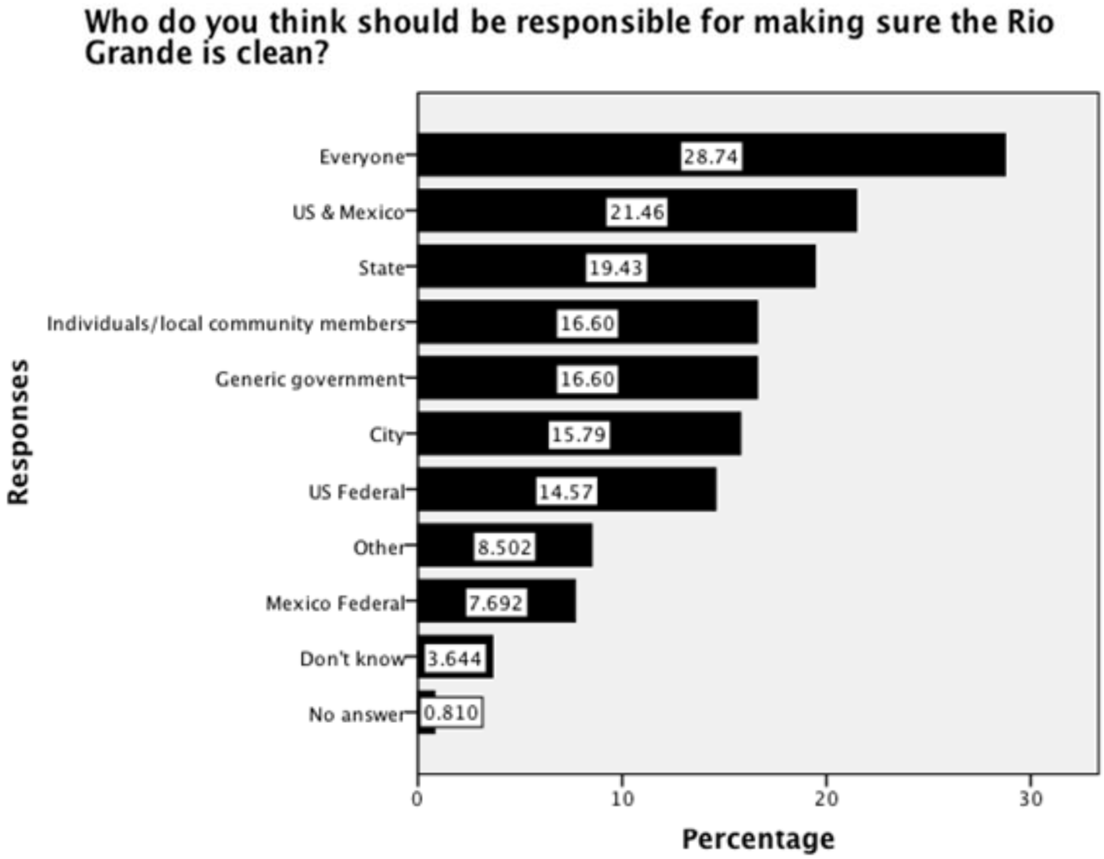
Figure 5.13 How to Improve Rio Grande/Río Bravo Water Quality



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

When asked about who or what institutions ought to be responsible for Rio Grande/ Río Bravo water quality (see Figure 5.14), the most frequent response was "everyone" (28.7 percent), followed by "Generic Government" (16.6 percent), "City" (15.8 percent), "State" (19.4 percent), or "U.S. Federal" (14.6 percent). 21.5 percent of respondents mentioned cooperation between the "U.S. & Mexico." Many respondents listed more than one answer. When basing the count on the total number of responses, 62.1 percent identified a level of government that should be responsible. Some respondents specifically pointed out "city governments, then state and federal - but government," "everyone, citizens but ultimately government," and "the U.S. and Mexico since both use the water."

Figure 5.14 Who Should Assure that the Rio Grande/Río Bravo is Clean?

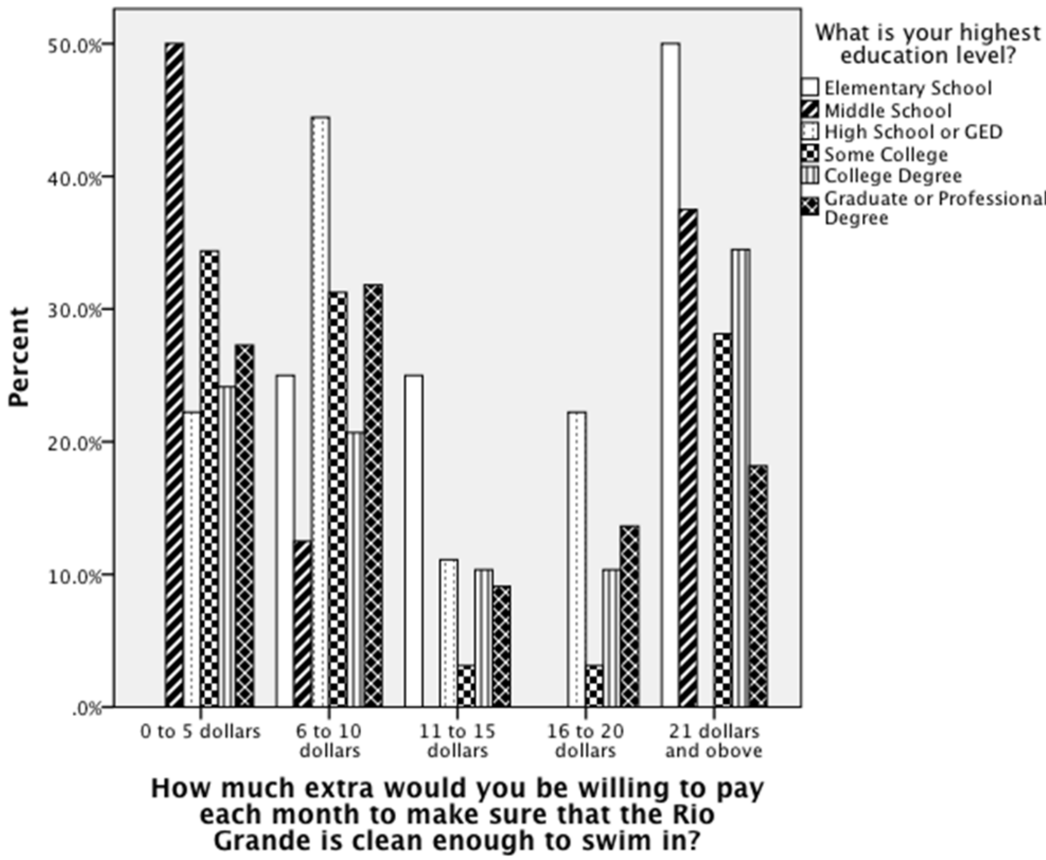


Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

A Chi-square analysis was conducted to determine if certain demographic groups were more or less likely to identify government (at any level) to be responsible for decreasing pollution. Results suggest that gender, education level, income level, and home ownership may affect respondents' propensity to seek government assistance. About 75 percent of males, 69 percent of respondents with some college education or higher, and 75 percent of homeowners identified government as responsible. This is in contrast to 55 percent of females, 54 percent of respondents with high school education or lower, and 50 percent of renters.

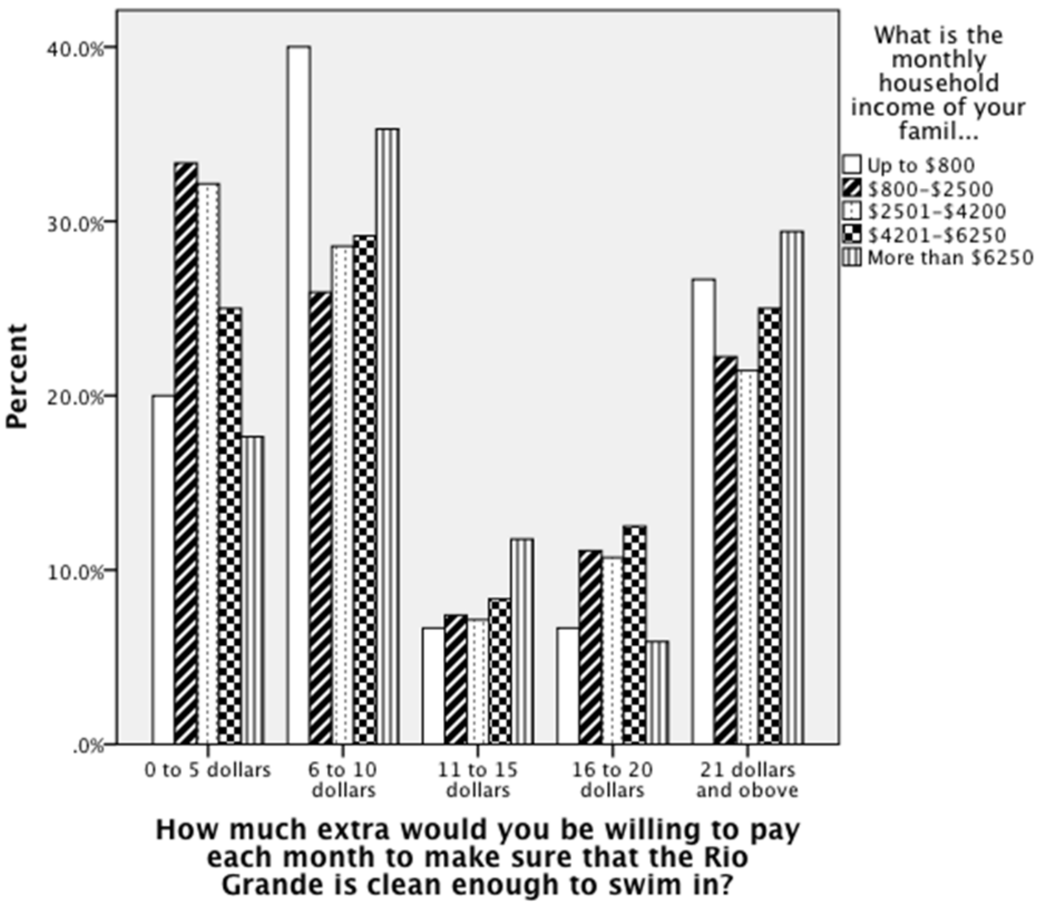
The survey asked stakeholders whether they are willing to invest in water quality improvements given their responses about the importance of water quality and the pollution level in the Rio Grande/Río Bravo. A majority (57 percent) of respondents said they would be willing to pay additional money as part of their monthly water bill to make sure that the Rio Grande/Río Bravo is clean enough to swim in. Chi-square results support these findings that willingness to invest is independent of demographic characteristics. Citizens with a lower education level or a lower income are actually more willing to pay just as much as higher income households for a clean Rio Grande (see Figures 5.15 and 5.16).

Figure 5.15 Willingness to Pay for Water Quality Versus Education



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Figure 5.16 Willingness to Pay for Water Quality Versus Income



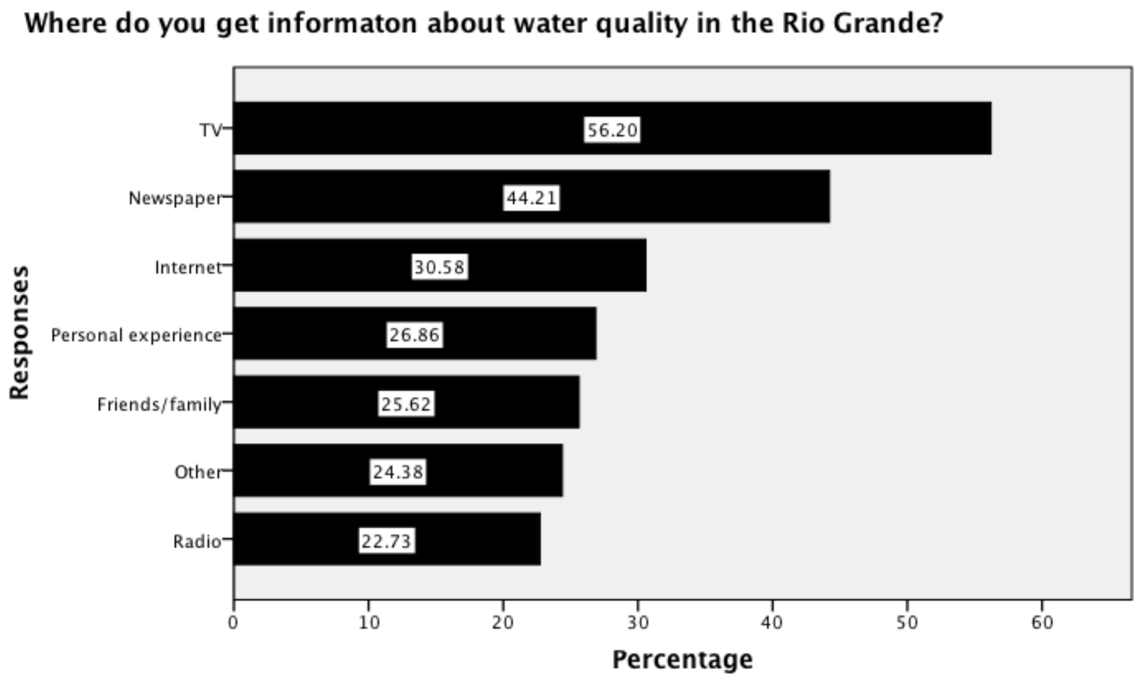
Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

The results illustrate that 50 percent of respondents who had completed elementary school education were willing to pay over $20, as compared to 20 to 30 percent of respondents at the higher income levels who indicated a willingness to pay $20 and above. Willingness to pay may be affected by how the survey was distributed. The random mail survey respondents were more willing to invest $16 or greater to improve water quality (44 percent of those who responded to the question) as compared to 21 percent of experts and only 6 percent of those sampled in person.

The survey also collected data on how residents currently receive information about water quality. Respondents were asked to check all sources that applied to them (see Figure 5.17). Television was the most frequent source of information, counting for 56.2

percent of total responses, followed by newspapers (44.2 percent), Internet (30.6 percent), and radio (22.7 percent).

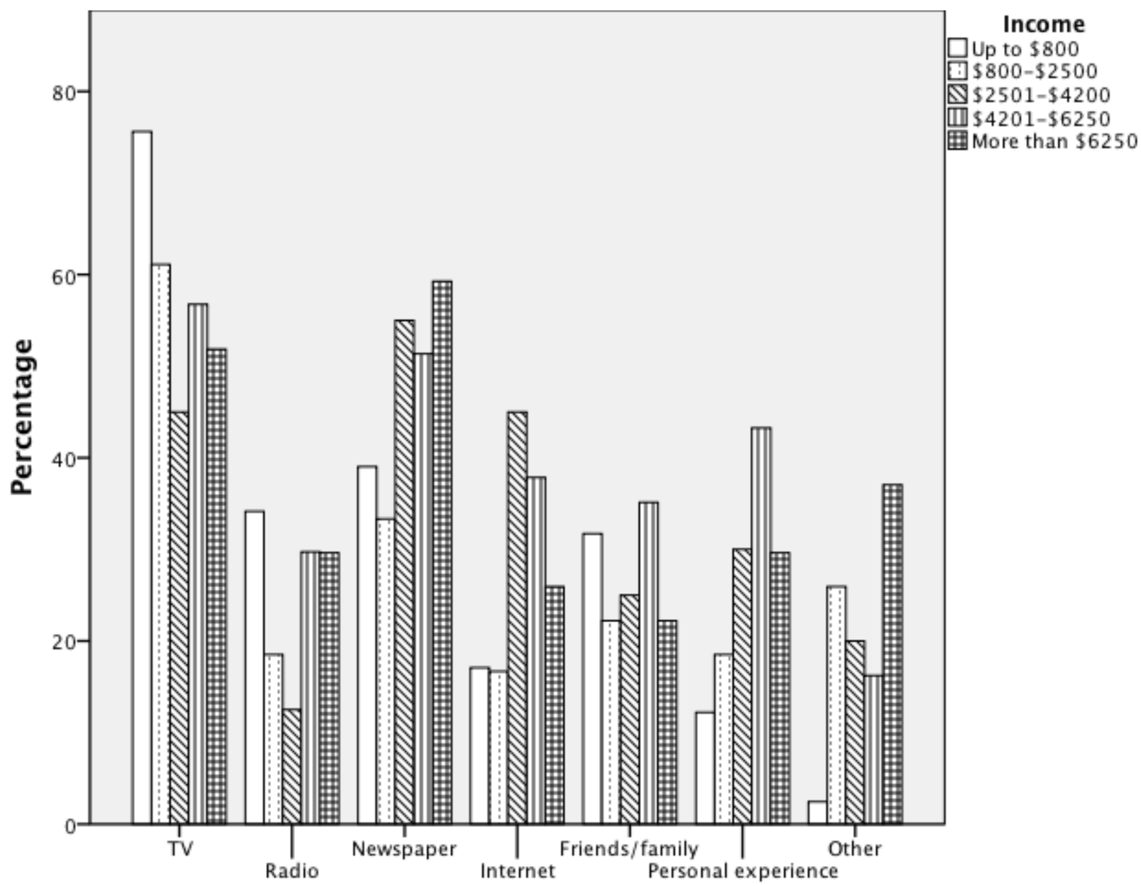
Figure 5.17 How Residents Receive Information on Water Quality



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

The responses were then cross-tabulated with income to explore if the preferred communication method differed among income classes (see Figure 5.18). Television was the most cited source of water quality information for low-income individuals (75.6 percent). In contrast, high-income residents were most likely to choose newspapers as their source of information (57.1 percent of total responses), although television is a close second. Middle-income households were mixed, with newspaper as the top source (51.1 percent) followed closely by television and Internet (46.7 percent and 42.2 percent). Chi square tests offer further support that the source used to gather information on water quality is dependent on income level. Disseminating information via both television and newspaper appear to be effective, with television preferred by low-income households.

Figure 5.18 Water Quality Information Sources Versus Income



Source: Data from two surveys of Lower Rio Grande communities collected by the Lower Rio Grande Water Quality Initiative (LRGWQI), 2012.

Conclusions

Texans who receive their water from the Rio Grande/Río Bravo believe that a clean river is important to the well-being of their communities. A majority indicate that the current ambient water quality does not meet their expectations. Respondents expressed concern over the current level of pollution which is affecting their lives negatively. In fact, residents with lower education levels expressed slightly greater concern over the level of pollution in the river, a stronger preference to keep the river clean, and they were also more willing to invest financially to see the water quality improved. The largest impetus for their concern is in the area of health. Residents' replies indicate that water related illnesses continue to be a problem in these areas.

Water users support investments to decrease pollution and improve water quality in the Lower Rio Grande/Río Bravo. Water stakeholders identified a range of suggestions to clean and treat wastewater, educate the populace about water borne diseases and decrease pollution from trash, sewage, and other contaminants. Stakeholders across all income ranges profess to be willing to invest in these solutions. Many respondents take responsibility personally or as a community for improving water quality. Sixty percent of respondents prefer an increased role for governments at some level to guide the process. Suggested roles for government investment include legislative enforcement of current pollution laws and standards, coupled with educational and technological improvements. A substantive proportion vocalized the need for Mexico and the U.S. to collaborate at a variety of levels (from federal to local) to create lasting solutions. If local, state, or federal governments offer comprehensive plans and projects to improve water quality, the survey results indicate area residents and water users will support their initiatives.

Interview Analysis

During the 2011-2012 school year, students conducted 27 interviews of various Texas government and community stakeholders along the Lower Rio Grande and transcribed the interviews. Project participants for the 2012-2013 school year have evaluated the interview transcripts to find common themes. Table 5.3 lists seven interview questions and the most common interviewee answers.

Interview answers are comparable to the survey results. These answers are also comparable to a previous survey of Mexican and U.S. citizens in Nuevo Laredo and Laredo, respectively, conducted during 1991-1992.[313] People who live along the border recognize its water quality problems and want to do something to improve water quality. They believe that their governments ought to act and truly are willing to pay themselves to improve water quality. These results are independent of demographic variables, including gender, age, income and education.

Table 5.3 Interview Questions and Common Answers

Question	Common Answers
What is the problem?	A majority of interviewees answered: • Pollution • Bacteria • Salinity Other answers included: • Blocked water flow due to algae blooms • Decreased water supply • Fertilizers • Pesticides • Total dissolved solids
What is the cause of the problem?	A majority of interviewees responded: • Population

	• Drought • Untreated wastewater • Untreated stormwater Other answers included: • Agricultural runoff • Trash • Inadequate infrastructure • Livestock waste • Over capacity treatment plants
What can be done?	A majority of interviewees answered: • Education • Improve infrastructure • Local focus Other answered included: • Stricter enforcement • Better treatment processes • Follow-up projects • Banning plastic bags • Installation of aerators throughout city • Accountability • More inspectors • Drip irrigation • Improve standards
What circumstances help communities improve water quality?	A majority of interviewees answered: • Monitoring and research • International and stakeholder cooperation • Good relationships with irrigation districts Other answers included: • Local research • Better water management • Planning and grants • The Rio Grande regional water authority has agreed to finance a SCADA system monitoring • NADABANK and BECC are introducing successful environmental projects
What are the barriers to solutions?	A majority of interviewees answered: • Lack of funding • Lack of international and stakeholder cooperation • Bureaucracy Other answers included: • Public interest • Opposition to regulations • Turnover of decision makers
What would be an ideal outcome?	A majority of interviewees answered: • Water of a quality that allows for edible fish • Water of a quality that allows for swimming and boating • Water of a quality that allows for bathing Other answers included:

	• Softer water • Lower levels of nutrients • Less presence of invasive plants • Decrease in diseases from poor water quality
How can a community identify whether progress is being made?	A majority of interviewees answered: • A reduction in bacteria levels • A reduction in salinity • A reduction in total dissolved solids • An increase in dissolved oxygen • An improvement in overall water quality Other answers included: • System improvements in irrigation districts • A decrease in frequency of diseases from poor water quality

Endnotes

[311] 2010 U.S. Census, available at http://quickfacts.census.gov/qfd/states/48/48427.html.

[312] Ibid.

[313] Eaton, David J., and David Hurlburt, "Chapter 6," *Challenges in the Binational Management of Water Resources in the Rio Grande-Rio Bravo*, Austin., Tex.: Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, 1992, 109-131.

Chapter 6. Possible Solutions

This chapter outlines some general guidelines as to how the problems of water quality in the Lower Rio Grande/Río Bravo could be ameliorated in the future. As part of the Lower Rio Grande Water Quality Initiative, managers of water infrastructure were asked to identify specific projects that could improve water quality in the Rio Grande/Río Bravo. Table 6.2 in this chapter lists their suggestions for community programs to improve water quality and Table 6.3 lists some best practices for dealing with animal wastes in proximity to water sources.

Proposed Solutions

Reclaimed wastewater can reduce a community's demand for treating freshwater to drinking water standards. Reclaimed water, with its nutrients, can be beneficial in some cases to plants and grass and can reduce the need for fertilizer. Reused water, or reclaimed water, has been approved by the TCEQ for the following uses: city parks, school playgrounds and sports fields, landscape nurseries, sports complexes, golf courses, street median landscaping, construction projects, street sweeping, fire protection, residential landscaping, apartment landscaping, industrial cooling towers, and industrial processes.[314] For example, the El Paso Water Utilities (EPWU), which has reused wastewaters since 1963, now supplies over 5.83 million gallons per day of reclaimed water to golf courses, city parks, school grounds, apartment landscapes, construction and industrial sites. Reclaimed water is being used to recharge the Hueco Bolson aquifer through injection wells and infiltration basins, and for cleaning operations within El Paso's WWTPs.[315]

General improvements to wastewater collection systems include monitoring and cleaning sewer lines to enhance flow, clearing roots that puncture pipes, and repairing and/or replacing cracked and broken pipes. Cities on both sides of the border seek to improve wastewater collection and treatment operations and maintenance, as well as to expand their systems. For example, when plant treatment volume reaches around 70 percent capacity, most communities would initiate planning so that system expansion could be completed before flows exceed the current infrastructure's capacity. Education and outreach to voters is an important component, as local support is important if tax dollars finance these projects. Combined system effluents can be reduced through flow monitoring, manhole inspection, and sewer line cleaning. Parallel wastewater and stormwater sewers reduce rainfall overflow events. Treatment systems can be improved by monitoring the quality and flow of wastewater.

Adding a separate stormwater sewer to supplement a wastewater collection system can reduce wastewater surge events that add bacteria to a river during rainstorms. However, paying for a separate stormwater sewer may be beyond the budget of communities with existing combined sewers. Best management practices (BMPs) can reduce the pollutant load even from combined sewer/stormwater systems through dry detention basins, infiltration, field rain gardens, wetlands, set retention ponds, and curb elimination.[316]

Combined system problems can be prevented in new developments if separate sewage collection and storm drain systems are built.

Maintenance of a wastewater system involves monitoring flow, inspection of cleaning of pipe sewer lines, and planning for expansion before a system exceeds capacity. For example, Leonardo Olivares, the city manager of Weslaco, Texas, stated that his community plans a future expansion as soon as treatment reaches 70 percent of current capacity.[317] Mr. Olivares indicated that outreach and education, particularly providing information to voters on the importance of improving wastewater infrastructure, are important parts of planning to encourage timely decisions about expansion and improvements.[318]

For areas with installed septic systems, there are ways a homeowner can minimize leakage or system failure, such as reducing the volume of water and waste entering a septic tank, distributing effluent more evenly using perforated piping in the leeching fields, supplemental treatment of septic tank effluent through on-site mounds or filters to augment the absorption field's capacities, and routine septic tank cleaning. Some operational septic problems can be resolved by a shift of solvents or educating users on upper limits to waste volume and how to handle system clogging.

Routine septic system maintenance inspections are considered a best management practice, as "regularly maintaining your septic system is much cheaper in the long run than having to replace because of problems that can occur from a lack of maintenance."[319] It costs a few hundred dollars to pump out a tank (around $75-$125 for a 500 gallon tank, or $250-$300 for a 1000 gallon tank), while replacing a system can cost thousands of dollars.[320] The suite of BMP's for routine maintenance includes elimination of in-sink garbage disposals; installation of low-volume plumbing fixtures; use of on-site mounds (sand), peat fields or sand filters; effluent distribution via low-pressure pipe systems; restricting use of organic solvents; inspection and maintenance; owner education; and identification and replacement of failing systems. EPA has tested color-infrared photography to locate failing septic tanks, which is at a lower unit cost than field studies.[321] The choice of which BMP to implement in a given situation depends on the circumstances, as indicated in the cases discussed below.

Although septic systems are considered the standard for on-site wastewater treatment, sustainable on-site alternatives exist, such as aerobic or sludge treatment units, recirculating or trickling filters, subsurface drip systems, and outflow to peat fields. Installation costs of these alternatives range from $3,500 to $25,000,[322] versus the installation of a traditional septic tank that costs between $2,000 and $6,000.[323] Given the costs, on-site alternatives to septic systems may not be feasible in poorer communities.

In 2000, the town of Nags Head, North Carolina instituted a free septic inspection program for maintaining and replacing septic tanks for protection of local waters.[324] If an inspection indicates that a system should be pumped, the owner would receive a $30 water bill credit after evacuation. By 2009, over 3,000 systems had been inspected under this program.[325] Todd Krafft, the Water Quality Coordinator for Nags Head, reported that this program continues to prompt 200 to 300 septic tank inspections per year, while before the recession the inspection rate was between 400-500 inspections per year. While the initial annual budget for the town's water quality initiative was approximately $500,000, the current annual expenditure of around $189,000 is leading to a success. Krafft estimates that the septic tank inspection portion of the program costs $75 per inspection.[326] At that rate, a system could be inspected annually for over ten years for less than the cost of replacing the system once, confirming the point made by maintenance proponents that inspecting and maintaining a system is less expensive than replacing it.

In 2005, the Jamestown S'Klallam Tribe (the Tribe) of Washington State created a Targeted Watershed Plan that included septic-related provisions as part of a larger effort to remediate water quality impairments in the Dungeness River. The Tribe offered a set of classes led by professionals ("Septic 101"), teaching homeowners how to maintain a healthy septic system. The Tribe incorporated a cost-sharing element, as any program attendee could be reimbursed up to 50 percent for septic system maintenance costs and minor repairs; permit fees were often waived as well.[327] If an owner had attended the class and needed to replace a system, a specialist could facilitate cleanup and help the owner obtain funding.[328] Septic professionals were offered training to increase their familiarity with best practices and regulations. The Tribe distributed a brochure to homeowners to inform them that minor routine maintenance is less expensive than septic system replacement. The septic management education and training portion of the watershed plan cost around $250,000. Results of these initiatives were assessed via a survey of septic system owners and through ongoing water quality monitoring.[329] Surface water quality surveys "have not shown an improvement…with respect to fecal coliform bacteria in the Dungeness Watershed or Bay within the last 10 years,"[330] although water quality conditions have not declined within the watershed either. The stable water quality is "notable considering the steadily increasing regional population, a greater use of on-site sewage treatment systems, and the shift in land use resulting in increased impervious surfaces. The apparent 'steady state' condition of water quality may be due in part to best management practices and outreach programs implemented while development proceeded."[331]

These U.S. case studies indicate that education, cost-sharing, incentives, and proper maintenance can improve septic system performance in non-sewered areas, and thus decrease pollutant loadings in nearby waters. One international case is the Community of Vida Verde in Costa Rica that augmented traditional septic systems with aeration chambers in which aerobic bacteria helped to break down wastes.[332] The effluent from these biodigestive septic systems is "treated with a small amount of chlorine and is safe to use for irrigation" of lawns and gardens.

There are no easy solutions to limit wildlife waste by providing alternative waste sources or population control. The recommended solutions regarding domestic pet waste is to dispose of it safely. This can be done by flushing it down the toilet, burying it or throwing it in the trash.

Buffer zones (vegetation on either side of a streambed) represents one exemplary management practice to filter out sediment, pesticides and other pollutants that could affect the watershed adversely. For example, a buffer zone can reduce sediment loads by a factor of three to four, and nitrogen by between 40 to 100 percent.[333]

The Plum Creek Watershed Partnership has tested techniques for decreasing feral hog populations. According to the Partnership, "once feral hogs are established in an area, complete eradication is almost impossible. There is no "silver bullet" or a single quick fix. However, by using multiple approaches, landowners and managers can limit the size of feral hog populations and reduce the level of damage. Their techniques include recognizing feral hog signs' use of corral or box traps' baiting feral hog traps' door modifications for feral hog traps' and snaring feral hogs. Although the technical means for control of animal waste problems are known, they are rarely implemented.[334]

Reducing bacterial loads will improve water quality in the Lower Rio Grande/Río Bravo from both the U.S. and Mexico portions of the watersheds 2301 and 2302. Both Texas and Mexico still know the options as discussed below.

Suggested Solutions from Managers

On March 20, 2013, a focus group was conducted to propose innovative and pragmatic investment projects or ideas to help improve water quality in the Lower Rio Grande Watershed (see Table 6.1). These ideas included repairing the Murillo Drain (a relatively low-cost, high-benefit project) to reduce the probability of leakage and the risk of pollution by high salinity. Another suggestion was for Mexican and U.S. operators to work together to discuss sewage collection and treatment system maintenance via conferences, compressed videos, or hands-on training. The idea of an automated water quality monitor was also raised to collect data and encourage upkeep of water quality. Other ideas included: (a) joint/regional waste utility; (b) city-to-city agreements across the border to address non-point source contamination; and (c) providing financial support for sewer plants and water line extensions. All focus group participants advocated community education and involvement. Education of children and parents through multiple media to encourage participation in water quality is an important step in achieving quality improvements.

Table 6.1 Options for Improving Rio Grande/Río Bravo Water Quality

Education and outreach	Establish community, in-school K-12 outreach programs related to conservation efforts and the process of water and wastewater treatment
Partnerships across governments	Share data between the Mexico and U.S. sides of the border and cooperate on matters of water quality
Equipment	Replace old and out-of-date equipment, such as clay pipes
Alternative water sources	Develop alternative sources of water for drinking purposes
Treated wastewater reuse	Reuse treated wastewater rather than discharge it into the river
Facility capacity	Expand the capacity of existing, traditional wastewater treatment plants to accommodate growing populations

Treated stormwater	Treat stormwater and runoff before it returns to the river and create new storage options for this water
Wetlands	Develop wetlands to form a natural filtration system before water reaches the river
Training	Create training programs for wastewater planners, engineers and plant operators

Source: Comments from focus group participants on March 20, 2013, Laredo, Texas.

Rio Grande stakeholders proposed other ideas, such as: (a) investing in education and outreach through in-school programs; (b) community outreach programs related to conservation; (c) community education about the process of water and wastewater treatment; (d) creating partnerships across governments through shared data and collaboration among city outreach and technical projects; (e) improving water and wastewater collection lines; (f) securing alternative sources of water; and (g) reducing the volume of water withdrawn from the Rio Grande. Recycling water using purple pipe technology allows wastewater to be recycled for non-drinking uses rather than being discharged into the river, which reduces the draw from the river for uses like agriculture. Several other ideas included treating stormwater and runoff before it returns to the river, creating storage options, developing wetlands, investing in human capital (especially planners and engineers), and maintaining transparency with public and alternate discharge channels.

Tables 6.2 and 6.3 outline some best practices with regard to improving water quality from the EPA and the George Soil and Water Conservation Commission, respectively.

Table 6.2 EPA Suggestions for Community Programs to Improve Water Quality

- Include decentralized systems in wastewater treatment training and certification programs and educate homeowners in “proper operation and maintenance and the consequences of failures.”
- “States should consider consolidating legal authority for centralized and decentralized wastewater systems under a single agency,” rather than having multiple agencies at the state and local levels splitting the duties related to wastewater management. Types of decentralized systems should also be selected for use based on their suitability for public health and environmental needs.
- Organizational structures should be established to properly manage the setting, design, installation, operation and maintenance of on-site systems and to ensure that public health and environmental standards are maintained.
- Appropriate management plans can help to avoid liability issues by helping to prevent failures, and low-costs system designs can be encouraged by decoupling engineering fees from the project cost.
- Water and waste disposal loans and grants from the U.S. Department of Agriculture’s Rural Utility Service are available to private corporations that are nonprofit; Clean Water SRF and CWA Section 319 programs (both through the EPA) can also support private entities.

• Educating community officials on available funds and their eligibility status can help address funding problems.

Source: Ninyo and Moore, "Improvements to the Wastewater Collection System for Camargo, Tamaulipas, Mexico," Transboundary Environmental Information Document, El Paso, Tex., August 14, 2009.

Table 6.3 Management Practices Limiting Bacteria Discharge from Animal Waste

Alternative water sources	Provide livestock with alternative water sources away from areas of environmental concern. Options include watering ramps, spring developments, wells, etc. to prevent water contamination from animal manure.
Fences, use of exclusions	Build structures that limit animal, human and wildlife entry into certain areas to protect natural resources and reduce the quantity of bacteria entering water sources through fecal coliform. "Fences have been found to reduce nitrogen by 60%, sediment by 75% and suspended solids by 50-90% in studies. Fencing animals out of small, second order streams has reduced fecal coliform colony forming units by 99% in studies."
Land use as a filter treatment	Land cutbacks in effect treat wastewater by reducing nutrients and pathogens in runoff, as the strips allow time for the soil to absorb them. "In studies, treatment strips trapped 80-90% of solids in feedlot runoff with shallow and uniform flow, and removed 60% of the total phosphorous and 70% of the total nitrogen." This method can also be used to reduce the runoff from feeding operations, usually at a low cost.
Land application	Land application of animal manure and contaminated water from livestock and poultry operations can utilize excess waste in a productive manner.
Animal mortality facilities	An on-site facility for treatment or disposal of livestock and poultry carcasses (burial pits, mortality composting facilities, incinerators and freezers) can reduce water contamination. These facilities are usually built as part of a waste management plan. The costs can vary depending on the size of the operation. Residuals from such facilities can also be used to improve soil.
Composting facilities	Composting utilizes animal manure and other waste in a sanitary way to provide a product that can enhance the soil's organic matter. This provides an alternative method to dispose of such animal waste that may otherwise enter the water. These facilities should not be in proximity to a stream or other water body.
Riparian forest buffers	Buffers of trees and soil cover use plants as biological filters to reduce organic matter in surface runoff alongside waterways, usually at moderate cost.
Manure storage facilities	On-ground structures can store animal manure, wastewater or contaminated runoff temporarily as part of an agricultural waste management system. "In studies, the amount of fecal coliform was reduced by 96% in litter that was stored for two weeks."
Anaerobic digesters	This method biologically treats animal manure using either an unheated or a managed temperature waste treatment facility. These systems can

	be costly, but are effective at reducing discharged fecal coliform.
Waste facility covers	Waste facility covers reduce unexpected overflow of waste storage facilities but are expensive.

Source: The Georgia Soil and Water Conservation Commission, "Best Management Practices for Georgia Agriculture: Conservation Practices to Protect Surface Water Quality," March 2007, 2.25, accessed May 6, 2012, available at http://www.gaswcc.org/docs/ag_bmp_Manual.pdf.

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Appendix A. Survey Materials

The following duel-language survey was distributed to leaders of organizations involved with water quality and residents of the Lower Rio Grande Valley. Three methods of distribution were utilized: a site-administered field survey, a random-sample mail survey, and a mail survey to responsible officials of water quality organizations. All recipients had the option to respond to the survey in English or Spanish.

Survey of Water Quality Preferences (English)

Lower Rio Grande Watershed Initiative (University of Texas at Austin)

The purpose of this survey is to gather information about water quality where you live. Your answers will help us understand local attitudes about water quality in the Rio Grande. If you are not sure about an answer, simply write "Not sure." <u>All answers will be kept completely anonymous</u>.

1. On a scale of 1-5, how important is it to you that the Rio Grande be clean? *Please circle <u>one</u> number.*

1	2	3	4	5
Not important				*Very important*

2. Why did you choose this answer?

____

____

3. Would you in the near future do the following activities in the Rio Grande?

□ Yes □ No Go swimming or wading?

□ Yes □ No Participate in water sports (boating, canoeing, water skiing, etc)?

□ Yes □ No Go fishing?

□ Yes □ No Let your dog go swimming?

4. Is it important that people be able to do the above activities in the Rio Grande? □ Yes □No

5. On a scale of 1-5, how polluted is the Rio Grande in your opinion? *Please circle <u>one</u> number.*

1	2	3	4	5
Not polluted				*Very polluted*

If you chose "1" please SKIP TO QUESTION 9. If you chose 2, 3, 4 or 5 please answer questions 6-8, below.

6. What do you think is the **biggest** source of pollution in the Rio Grande?

____

____

7. How do you think pollution in the Rio Grande affects someone like you?

____

____

8. Who do you think **should be** responsible for making sure the Rio Grande is clean?

____

____

9. Where do you get information about water quality in the Rio Grande? *Check all that apply.*

□ TV □ Radio □ Newspaper □ Internet

□ Friends/Family □ Personal experience

□ Other____

10. What do you think should be done to improve water quality in the Rio Grande?

____

____

11. About how much is your water bill each month?

____

12. How much extra would you be willing to pay **each month** to make sure the Rio Grande is clean enough to swim in? ____

13. What year were you born? ___________________________

14. Were you born in Starr, Willacy, Cameron or Hidalgo county? □ Yes □ No

15. What is your gender? □ Male □ Female

16. Do you consider yourself Latino or Latina?

□ Yes □ No

17. What is your highest education level?

Please check one of the boxes below.

- □ Elementary School
- □ Middle School
- □ High School or GED
- □ Some College
- □ College Degree
- □ Graduate or Professional Degree

18. How many years have you lived in your current home? ________________

19. What is the **monthly** household income of your family?

□ Up to $800 □ $4,201 – $6,250

□ $800 - $2,500 □ More than $6,250

□ $2,501 – $4,200

20. Do you or someone in your family own your home or is the home rented? □ Own □ Rent

Encuesta de Preferencias de Calidad del Agua (ESPAÑOL)

Iniciativa de la *Cuenca del Bajo Río Grande/Río Bravo* (Universidad de Texas, Austin)

El propósito de esta encuesta es obtener información sobre la calidad del agua donde usted vive. Sus respuestas nos ayudarán a comprender las actitudes acerca de la calidad del agua en el Río Grande/Río Bravo. Si no está seguro/a de una respuesta, simplemente escriba "No estoy seguro/a." Todas sus respuestas se mantendrán completamente anónimas.

1. En una escala de 1-5, ¿qué tan importante es para usted que el Rio Grande/ Río Bravo esté limpio? *Por favor circule solo uno numero.*

1 2 3 4 5

No importante Muy importante

2. ¿Por qué eligió esta respuesta?____

____

3. ¿Haría usted las siguientes actividades en el Río Grande / Río Bravo?

□ Sí □ No ¿Nadar o meterse en el agua?

□ Sí □ No ¿Participar en deportes acuáticos (canotaje, esquí acuático, etc…)?

□ Sí □ No ¿Pescar?

□ Sí □ No ¿Dejar que su perro nade?

4. ¿Es importante que la gente sea capaz de hacer cualquiera de las actividades mencionadas anteriormente? □ Sí □ No

5. En su opinión, en una escala de 1-5, ¿qué tan grave es la contaminación en el Rio Grande/ Río Bravo? *Por favor circule* *solo uno* *numero.*

1 2 3 4 5

No contaminado *Muy contaminado*

Si contestó "1" por favor SALTE A PREGUNTA 9. Si contestó 2, 3 ,4 o 5 por favor conteste preguntas 6-8 abajo.

6. ¿Qué cree usted que es **la mayor** fuente de contaminación en el Río Grande/Río Bravo?

____

____

7. ¿Cómo cree usted que la contaminación en el Río Grande afecta a alguien como usted?

____

____

8. ¿Quién cree usted que **debería** ser responsable de asegurar que el Río Grande/Río Bravo esté limpio?

____

____

9. ¿Donde consigue usted información sobre calidad de agua en el Rio Grande/Río Bravo? Por favor *marque* *todo* *lo que corresponda.*

□ TV □ Radio □ Periódico □ Internet

□ Amigos/Familia □ Experiencia Personal

□ Otra Cosa? ______________________________________

10. ¿Qué cree usted que se debería hacer para mejorar la calidad del agua en el Río Grande/Río Bravo?

____

____

11. ¿Aproximadamente cuánto es su factura del agua cada mes?

____

12. ¿Cuánto más estaría usted dispuesto a pagar **cada mes** para asegurar que el Río Grande/Río Bravo sea lo suficientemente limpio para nadar? ____

13. ¿En qué año nació usted? ____

14. ¿Nació usted en el condado de Starr, Willacy, Cameron o Hidalgo? □ Sí □ No

15. ¿Cuál es su sexo? □ Masculino □ Femenino

16. ¿Se considera usted Latino o Latina? □ Sí □ No

17. ¿A que nivel de educación a llegado usted? *Marque una de las cajas abajo.*

□ Elementary School (Primaria)

□ Middle School (entre primaria y secundaria)

□ High School o GED (Diploma de escuela secundaria o su equivalente)

□ Algunos Estudios Universitarios

□ Título Universitario

□ Título Universitario de Postgrado o Profesional

18. ¿Por cuántos años ha vivido usted en su hogar actual? ____________________________

19. ¿Qué es su ingreso familiar **mensual**?

□ Hasta $800 □ $4,201 – $6,250

□ $800 - $2,500 □ Más de $6,250

□ $2,501 – $4,200

20. ¿Es usted o alguien de su familia el dueño de la casa o es la casa alquilada? □ Dueño □ Alquilad

Chi-Squared Test Results

Chi-Square tests were conducted to further explore the impact of demographic attributes and survey distribution method on water quality preferences. The associations tested include the perceived importance of water quality (Question 2), the perceived level of current pollution (Question 5), the perceived effects of pollution (Question 6), the desire for government to take responsibility for improving water quality (Question 8) and the willingness to pay for better water quality (Question 12). Chi-square tests were also conducted between monthly household income (Question 19) and information source (Question 9). Due to the variety of possible responses to open-ended questions, answers to several questions were combined and reorganized in order to satisfy the minimum expected cell count required for valid test results. Answers were reclassified as discussed below.

Table A1. Categorizing of Survey Answers for Chi-Squared Tests

Variable/Question	Categorized Answers
Age	18 to 54 55 and above
Education Level	High school and below Some college and above
Years in current home	0 to 15 years 16 years and above
Income	Below $2500 Above $2501
How polluted is the Rio Grande?	Somewhat or less than somewhat polluted Polluted or very polluted
How important is the Rio Grande being clean?	Below very important Very important
Should any level of government (American or Mexican) be responsible for improving water quality?	Various answers
Should someone other than the government be responsible for improving water quality?	Various answers

Table A2 to A19 contain the chi-square analysis of questions, attributes, and independence of variables.

Table A2. Demographic Variables and Water Quality

	Importance of Water Quality		Independence
Age	Sig.	0.286	+
Birth place	Sig.	0.774	+
Gender	Sig.	0.112	+
Latino or not	Sig.	0.807	+
Education level	Sig.	0.354	+
Years live in current home	Sig.	0.611	+

Income	Sig.	0.952	+
*Home rented or not	Sig.	0.729	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

* means the minimum expected cell count is less than one, so the Chi-square result might be invalid.

Table A3. Demographic Variables and Pollution Level

	Pollution Level		Independence
Age	Sig.	0.008	-
Birth place	Sig.	0.332	+
Gender	Sig.	0.298	+
Latino or not	Sig.	0.008	-
Education level	Sig.	0.101	+
Years live in current home	Sig.	0.003	-
Income	Sig.	0.752	+
Home rented or not	Sig.	0.237	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A4. Demographic Variables and Pollution Effects on Health

	Pollution Effects on Health		Independence
Age	Sig.	0.579	+
Birth place	Sig.	0.582	+
Gender	Sig.	0.276	+
Latino or not	Sig.	0.933	+
Education level	Sig.	0.478	+
Years live in current home	Sig.	0.881	+
Income	Sig.	1.000	+
Home rented or not	Sig.	0.777	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A5. Demographic Variables and Pollution Effects on Recreation

	Pollution Effects on Recreation		Independence
Age	Sig.	0.176	+
Birth place	Sig.	0.230	+
Gender	Sig.	0.690	+
Latino or not	Sig.	0.950	+
Education level	Sig.	0.000	-
Years live in current home	Sig.	0.343	+
Income	Sig.	0.228	+
Home rented or not	Sig.	0.345	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A6. Demographic Variables and Government Roles

	Government is Responsible		Independence
Age	Sig.	0.918	+
Birth place	Sig.	0.954	+
Gender	Sig.	0.000	-
Latino or not	Sig.	0.713	+
Education level	Sig.	0.024	-
Years live in current home	Sig.	0.916	+
Income	Sig.	0.010	-
Home rented or not	Sig.	0.047	-

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A7. Demographic Variables and Willingness to Pay

	Willingness to Pay		Independence
Age	Sig.	0.938	+

Birth place	Sig.	0.760	+
Gender	Sig.	0.111	+
Latino or not	Sig.	0.744	+
Education level	Sig.	0.583	+
Years live in current home	Sig.	0.926	+
Income	Sig.	1.000	+
Home rented or not	Sig.	0.974	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A8. Income Information

	Income		**Independence**
Information source	Sig.	0.000	-

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A9. Water Quality Variables by Distribution

	Distribution Method		**Independence**
Importance of Water Quality	Sig.	0.977	+
Pollution Level	Sig.	0.601	+
Government Should be Responsible	Sig.	0.996	+
Pollution Effects on Cost of Water	Sig.	0.006	-
Pollution Effects on Health	Sig.	0.779	+
Pollution Effects on Recreation	Sig.	0.099	+
Willingness to Pay	Sig.	0.001	-

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

Table A10. Demographic Variables and Cost of Water

	Pollution Effects on Cost of Water		Independence
Age	Sig.	0.562	+
Birth place	Sig.	0.173	+
Gender	Sig.	0.027	-
Latino or not	Sig.	0.074	+
Education level	Sig.	0.058	+
Years live in current home	Sig.	0.991	+
Income	Sig.	0.297	+
* Home rented or not	Sig.	0.243	+

Alpha is set at 0.05

+ indicates variables are independent

- indicates variables are not independent

* means the minimum expected cell count is less than one, so the Chi-square result might be invalid.

Demographic Attributes of Survey Respondents

Below are the tables representing the raw data collected from the survey. Along with the frequencies noted below, the percentage of responses are shown below as well. Valid percentages represent the percentage value not counting missing data.

Table A11. Data on the Surveys Sent and Received

Surveys Mailed	1000
Surveys Returned	80
Surveys Delivered in Person	142
Expert Surveys Returned	30
Total Surveys Returned	252

Table A12. Gender of Persons Surveyed

	Frequency	Percent	Valid Percent
Female	117	46.4	48
Male	127	50.4	52
Total	244	96.8	100
Missing	8	3.2	

Table A13. Age of Persons Surveyed

	Frequency	Percent	Valid Percent
18 to 24	12	4.8	4.9
25 to 34	42	16.7	17.3
35 to 44	38	15.1	15.6
45 to 54	33	13.1	13.6
55 to 64	66	26.2	27.2
65 to 74	40	15.9	16.5
75 and above	12	4.8	4.9
Total	243	96.4	100
Missing	9	3.6	

Table A14. Survey Participants Born in Starr, Willacy, Cameron or Hidalgo Counties

	Frequency	Percent	Valid Percent
No	148	58.7	60.2
Yes	98	38.9	39.8
Total	246	97.6	100
Missing	6	2.4	

Table A15. Survey Participants of Latino/Latina Origin

	Frequency	Percent	Valid Percent
Not Latino/Latina	76	30.2	31.1
Latino/Latina	168	66.7	68.9
Total	244	96.8	100
Missing	8	3.2	

Table A16. Education Level of Persons Surveyed

	Frequency	Percent	Valid Percent
Elementary School	18	7.1	7.3
Middle School	14	5.6	5.7
High School or GED	41	16.3	16.7
Some College	65	25.8	26.5
College Degree	64	25.4	26.1
Graduate or Professional Degree	43	17.1	17.6
Total	245	97.2	100
Missing	7	2.8	

Table A17. Years Lived in Current Home of Persons Surveyed

	Frequency	Percent	Valid Percent
0 to 5 years	65	25.8	26.3
6 to 15 years	96	38.1	38.9
16 to 25 years	46	18.3	18.6
26 to 35 years	24	9.5	9.7
36 years and above	16	6.3	6.5
Total	247	98	100
Missing	5	2	

Table A18. Monthly Household Income of Persons Surveyed

	Frequency	Percent	Valid Percent
Up to $800	42	16.7	18.2
$800-$2500	58	23	25.1
$2501-$4200	49	19.4	21.2
$4201-$6250	46	18.3	19.9
More than $6250	36	14.3	15.6
Total	231	91.7	100
Missing	21	8.3	

Table A19. Persons Surveyed Owning or Renting a Home

	Frequency	Percent	Valid Percent
Renting	43	17.1	18.4
Owning	199	79	81.6
Total	242	96	100
Missing	10	4	

Appendix B. International Case Studies

This appendix describes cases in which nations manage cross-boundary river water quality in seven selected international basins. The basins represent a wide spectrum of economic and political conditions, from the European Rhine to the Mekong, from industrial basins to developing countries dependent upon agriculture and the export of primary products. These case studies could inform the United States and Mexico about ideas that could be used along the lower Rio Grande/Río Bravo.[335]

Case Study 1: The Lempa Watershed (Central America)

The Trifinio region at the intersection of El Salvador, Honduras, and Guatemala includes the Upper Lempa River basin, the Ulúa River, and the Montagua River. The Lempa is the longest river in Central America and one of the most important water resources for the people of the region.[336] For example, 72 percent of the water supply for El Salvador comes from the Lempa River.

The Trifinio Plan (the Plan) is a tri-national agreement among the governments of El Salvador, Guatemala, and Honduras aimed at "contributing to the Central American integration, through joint action in Guatemala, El Salvador and Honduras, which tends to the integral development, harmonious and balanced development of the border region of the three countries."[337] The Plan was developed in phases beginning in 1986 through a pilot plan funded primarily by the European Union that initiated the reforestation of 6,000 hectares of the Trifinio Zone in 1989. It was formalized by the creation of the Trinational Commission of the Trifinio Plan in 1997.[338] The Treaty was ratified by all three governments in April 1999.

The Treaty formally "recognize[s] the Tri-National Commission (the Commission), composed of the vice presidents of the Republics of Guatemala and El Salvador and one of the Appointed as President of the Republic of Honduras, as the entity responsible for overseeing the implementation of the Plan and its permanent Trifinio updates with administrative, financial, technical and legal status."[339] Table B1 lists the Commission facts. The Plan is executed by a Tri-national Technical Unit, a Consultative Committee of the region's mayors, the ATRIDES (Associations for Sustainable Development), NGOs who have worked in the region, and other civil society organizations to assistant the Commission in implementing the Plan.[340] Stakeholder involvement has increased over the years, especially in the processes of making Plan revisions and updates.[341]

The initial Plan was drafted in 1988 and has been revised twice in 1992 and 2004. For example, the 2004 Plan identifies specific pollution problems for the watershed, citing the primary cause to be the lack of education and the inadequate waste control: "There is a significant risk to the health of residents due to inadequate solid waste management in urban areas and low rates of access to basic sanitation in rural areas (water and waste disposal), causing high levels of fecal coliform contamination of water bodies in the area."[342]

Table B1. Functions of the Tri-national Commission of the Trifinio

- Act as a permanent body for coordination and consultation
- Serve as a high-level forum to discuss sustainable development issues in the Trifinio Region
- Approve policies, plans and annual programs
- Review and approves the adjustments and updates Trifinio Plan
- Accept donations and receives technical cooperation and grant aid required for its functioning and strengthening Amistad, Falcon, Anzalduas, and Retamal Dam maintenance and operation
- Approve the annual operating plans for the Tri-Executive Secretariat
- Seek the views of Trifinio Plan Advisory Committee
- Promote financial cooperation Water conservation in Mexican and U.S. irrigation districts
- Adopt its own rules of operation and rules of operation of the Executive Secretariat and the Advisory Committee

Source: Commission Trinacional Del Plan Trinifio, "Function of the Tri", trans. Google Chrome, available at http://www.sica.int/trifinio/ctpt/breve_ctpt.aspx?IdEnt=140.

The most recent Trifinio Plan revision includes goals for economic growth, infrastructure, social development, institutional development, and supporting ecosystem and watershed environmental needs through pollution control.[343] Table B2 lists some of plan's components with regard to pollution control.

Table B2. 2004 Plan for Bacterial Pollution Reduction

- Promotion of measures to reduce and control pollution of soil, water and air
- Facilitation of pollution control in three countries and raising awareness to bring about change in attitudes towards the environment
- Identification and implementation of technical and economical solutions for disposal of liquid waste, solid and gas concentrations generated by urban and industrial and mining activities
- Construction of treatment plants, sewage and solid waste for major urban centers in the region

Source: Commission Trinacional del Plan Trifinio, Trifinio Plan Update 2004, trans. Google Chrome, available at http://www.sica.int/busqueda/busqueda_archivo.aspx?Archivo=info_5241_4_10052006.htm.

The most relevant project thus far has been the Project for the Promotion of Water Management and Regional Public Good the Cuenca Alta del Rio Lempa Trifinio Region, which began in 2006. The primary goal of this project was the education of governmental and nongovernmental entities to promote water as a regional public good (RPG) to be managed through concrete actions to improve water quality and quantity. The project aimed to reach over 300,000 residents of the Trinfio region. It was funded by a grant from the Inter-American Development Bank and a small Trifinio Commission contribution.[344] According to the Commission's website, the project came to a close in 2009.

Funding for the Commission projects come from a variety of sources, including the International Development Bank (often accompanied by some counterpart funds from the three governments), the Norwegian Agency for Cooperation-NORAD, the Agency Cooperation-GTZ, German and Nordic Fund concessional funds, Japan Special Fund, and Central American Bank for Economic Integration, the United States, Sweden, Spain, the Netherlands, Germany, Canada, and Japan. Some funding has come from the three governments.[345]

According to a UNESCO publication, the Trifinio Plan has improved trans-boundary cooperation among El Salvador, Guatemala, and Honduras.[346] The fact that the vice-president of each country is the key national official responsible for the development and implementation of the plan means that any projects have national consent, the external support enhances transnational stakeholder cooperation. El Salvador has the greatest interest in improving the Upper Lempa Watershed water quality because both Honduras and Guatemala have other water sources. While 72 percent of El Salvadorians rely on the Lempa for their water supply, estimated data suggests that 90 percent of that water is considered polluted by untreated effluents, agrochemicals, industrial waste, and sediments.[347]

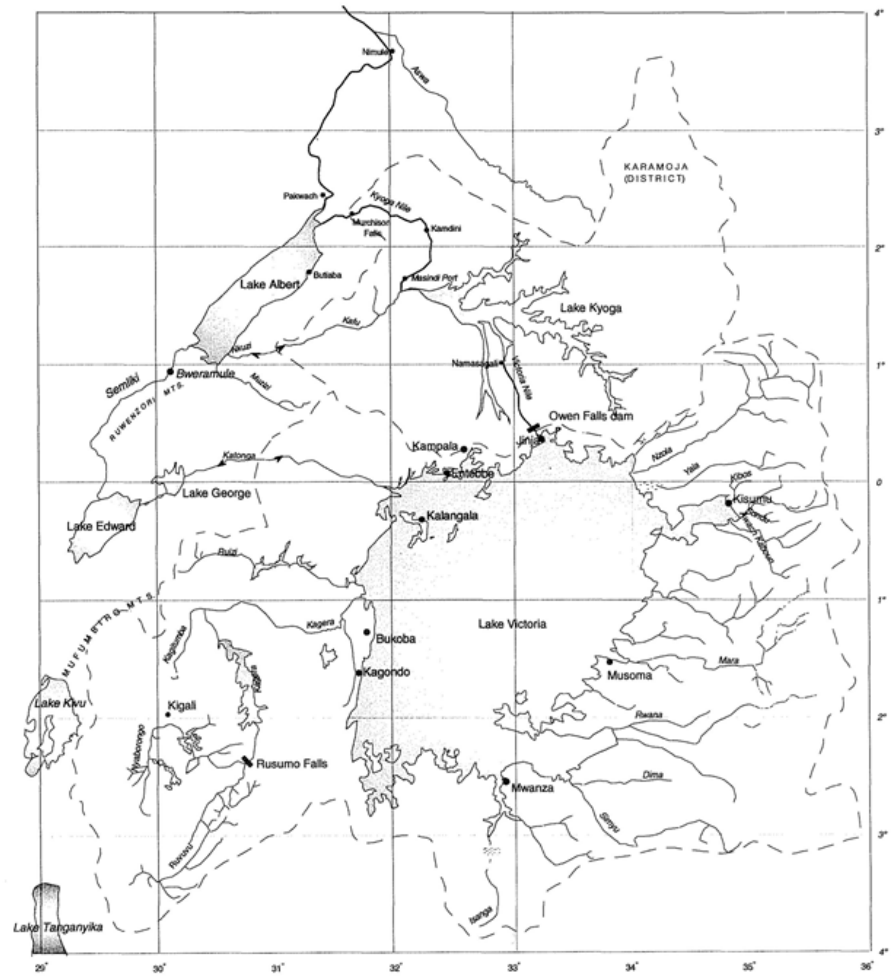
While increasing transnational stakeholder involvement has helped the plan become more successful over time, there has been little change in the water quality of the Upper Lempa basin. Despite the difficulties in better managing water quality, Alexander Lopez of the Mesoamerican Center for Sustainable Development of the Dry Tropics concludes in his report that:

> the Trifinio Plan…is the most concerted effort towards territorial integration and cross-border cooperation in Central America. The Plan's transboundary institutional framework and the formation of the ATRIDES laid the groundwork for a collaborative approach to regional management of the Lempa River basin. The Plan's programs have increased the sensitivity of government agencies and local populations to human impacts on the environment and to the need for integrated management of the basin.[348]

Case Study 2: Lake Victoria (Africa)

The Lake Victoria Environmental Management Project (LVEMP) was initiated in 1994[349] to reverse environmental degradation in the Lake Victoria watershed by the Lake Victoria Basin Commission (LVBC), which is composed of all five riparian states: Kenya, Uganda, Tanzania, Rwanda, and Burundi[350] (see Figure B1). Kenya, Uganda, and Tanzania drafted and signed an initial Protocol for Sustainable Development of the Lake Victoria Basin on November 23, 2003, as a multi-national effort to promote a unified approach for activities conducted within the Lake Victoria watershed. Rwanda and Burundi joined later.

Figure B1. Lake Victoria Basin Map



Source: Sutcliffe, J.V. and Y. P. Parks, “The Hydrology of the Nile,” IAHS Special Publication no. 5, February 1999, IAHS Press, Institute of Hydrology, Wallingford, Oxfordshire.

Managed by the LVBC, the Lake Victoria Water and Sanitation Initiative Project provides water and sanitation service to 10 mid-sized cities in Kenya, Tanzania, and Uganda. The second phase will extend the water and sanitation projects to the upstream countries of Rwanda and Burundi. In addition to water and sanitation services, the project will expand to invest in the countries’ institutional capacity to operate and maintain the facilities, enhance local urban planning and policy reforms, and “reduce the environmental impact of urbanization in the Lake Victoria Basin.”[351]

The Lake Victoria Environmental Management Project seeks to coordinate water regulations and policies, watershed management, and point-source pollution control.[352] One focus is on coordination of regulations and policies that affect economic development and the protection of fisheries. Other key management goals include the protection of human and ecosystem health from water borne diseases and industrial contamination.[353] Activities associated with point source pollution control and prevention focus on sanitation, wastewater treatment, cleaner industrial methods, navigation infrastructure, and a hazardous materials spill response framework.[354] Watershed management efforts focus on sustainable practices for soil and water conservation.[355]

A number of international sources are providing funding for the Lake Victoria Environmental Management Project, including the World Bank International Development Association,[356] the Global Environment Facility,[357] SIDA,[358] UN HABITAT,[359] the African Development Bank,[360] and the Netherlands.[361] The participating sovereign governments, local governments, utility providers, and water users contribute local funds.[362] Article 17 of the Protocol for Sustainable Development of the Lake Victoria Basin proposes that legal and regulatory means be used to ensure that polluters take financial responsibility for environmental degradation resulting from their actions. These funds would then be used for remediation by the participating country where the infraction occurred.[363] Authors of a policy paper evaluating mitigation options in the Lake Victoria watershed also point to private sector management of sanitation facilities to compensate for the lack of civic resources: "The feasibility and effectiveness of this policy option is that it is a business venture with the capability of generating income. There are, for example, environmental and sanitation companies in Dar es Salaam and other towns that are carrying out the enterprise profitably."[364]

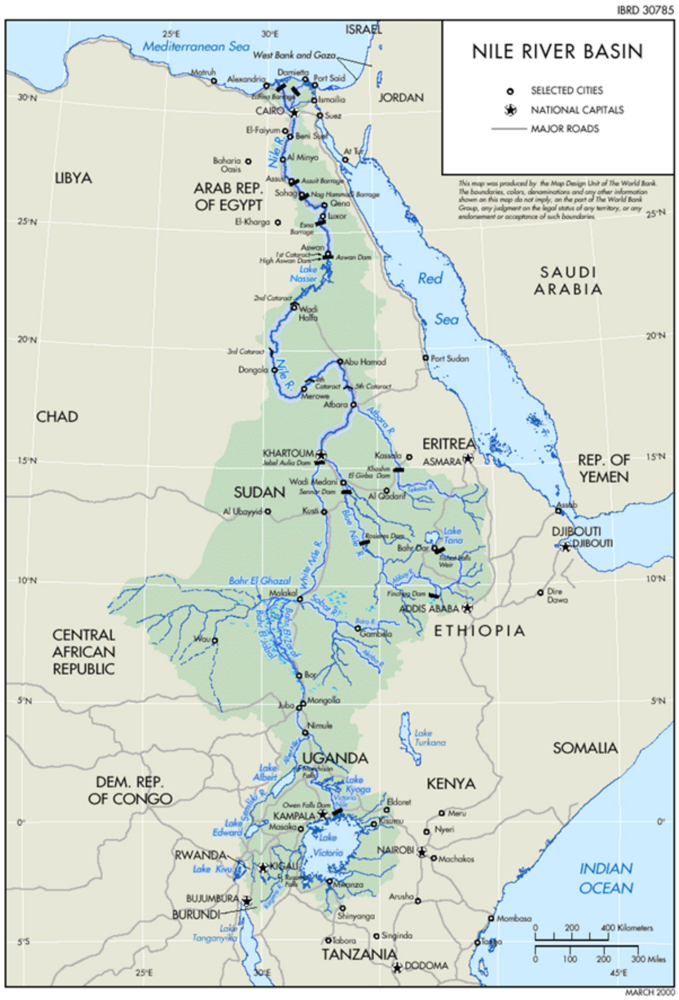
Stakeholder involvement in the LVEMP has encouraged participation by affected communities in projects and policies to protect the health of water resources, as well as long-term maintenance and management of sanitation facilities.[365] Member countries also recognize the link between environmental degradation and poverty.[366] Therefore, efforts to establish the willingness and ability to pay for sanitation facilities have been essential to the program.[367] The Lake Victory Basin Commission attributes much of its success to its institutional structure within established departments. "These institutional bodies can become the focal points to build capacity at the town and local level, especially in the crucial area of tendering and contracting."[368] The partners have trained local administrative officials in planning principles for effective follow-through. Existing LVBC documentation has yet to document water quality improvement.

Case Study 3: The Nile Basin (Africa)

The Ministers of Water Affairs of Burundi, the Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda formed the Nile Basin Initiative in 1999, with Eritrea in an observer capacity[369] (see Figure B2). Cooperation was initially focused on building trust and capacity within the participating governments to the point where large-scale projects could be developed;[370] their scope of interest has expanded to include common socio-economic interests.[371]

One of the first joint projects to be completed under the Nile Basin Initiative was the Transboundary Environmental Action Project. This project sought to strengthen institutions and establish baselines for basin-wide water quality monitoring. Table B3 lists some lessons learned from prior water initiatives financed through the Global Environment Facility that were incorporated into the project design.

Figure B2. The Nile River Basin Map



Source: The Nile River Initiative, available at http://www.nilebasin.org/newsite/.

Table B3. Lessons Incorporated into the Nile Basin Initiative

- Establish a common goal
- Move beyond past conflicts to promote opportunity
- Emphasize "sharing benefits not sharing water"
- Promote sustainable solutions for the prevention of water quality degradation where the water body is not already polluted critically
- Establish responsive legislation and policy at the highest levels of government
- Agree that subsidiary projects can be undertaken under the aegis of common goals
- Build trust at all levels (especially where past conflicts have occurred)
- Continue commitment beyond political and administrative changes
- Create multidisciplinary international partnerships and stakeholder buy-in
- Develop a strong institutional framework

Source: Project Appraisal Document on a Proposed Grant from the Global Environment Facility in the Amount of US$8.00 Million to the Nile Basin Initiative for Nile Trans-boundary Environmental Action Project, World Bank, Report No. 24609-AFR, March 5, 2003.

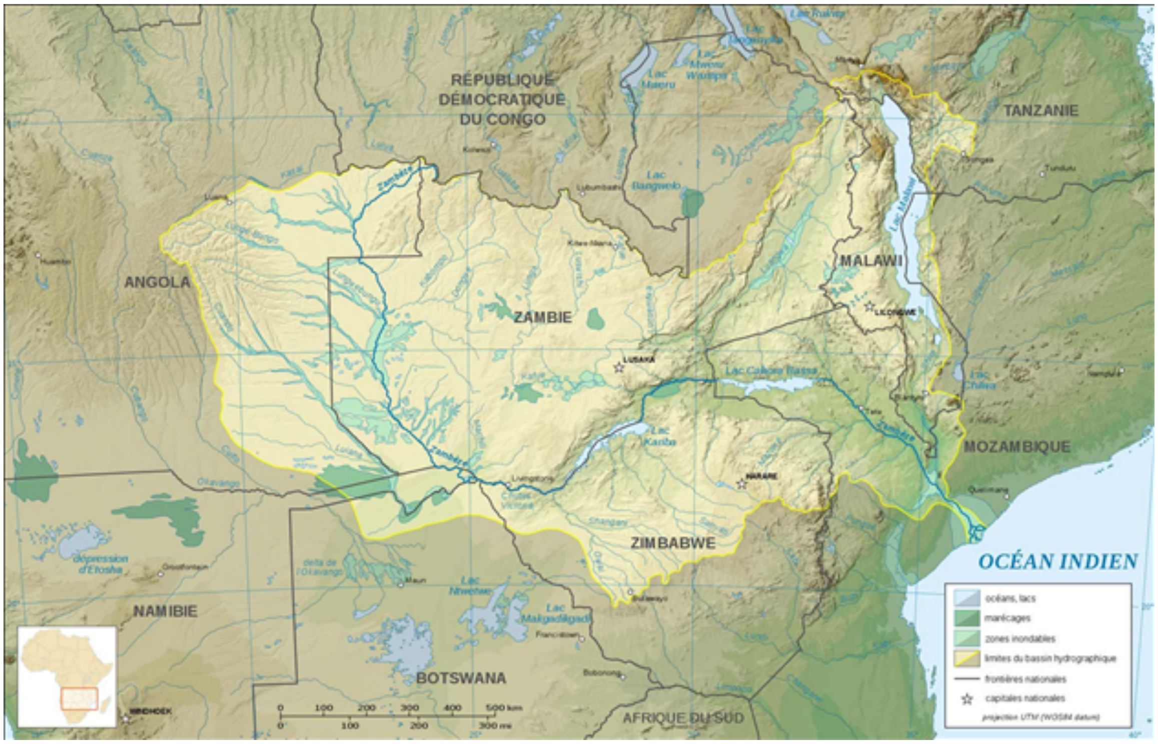
Case Study 4: The Zambezi River (Africa)

The Zambezi River Basin, the fourth-largest river basin of Africa, flows for 3000 kilometers from its source to the Indian Ocean, covering about 4.5 percent of the continent and spread over eight countries[372] (see Figure B3). On May 28, 1987, all eight riparian countries along the Zambezi River (Angola, Botswana, Mozambique, Namibia, Malawi, Tanzania, Zambia and Zimbabwe) signed an Agreement on an Action Plan for the Environmentally Sound Management of the Common Zambezi River System.[373] As of September 2011, six of the eight countries have confirmed the Agreement on the Establishment of the Zambezi Watercourse Commission (ZAMCOM), which provides the two-thirds majority needed for the agreement to take effect.[374]

The ZAMCOM manages and develops Zambezi River water resources, such as the Kariba Dam and Lake complex and monitors water quality. Water is collected regularly at 22 sites for testing on a series of parameters (some every month, every six months or once a year) in some of the Zambezi Basin nations.[375] For example, Malawi monitors for biochemical oxygen demand and nitrate in most of its major rivers,[376] while Mozambique has yet to implement water quality monitoring.[377]

The incidence of waterborne disease attributed to untreated sewage effluent is widespread in the Zambezi Basin. However, none of the participating countries have expressed concerns for water quality as a trans-boundary issue.[378] The South African Development Council (SADC) is quantifying the economic impact of water pollution in an effort to explain the link between pollution and poverty.[379] The SADC's evidence may encourage local governments, industry, and the private sector to invest in effluent treatment, as recommended by international policy analysts.[380]

Figure B3. The Zambezi River Basin Map



Source: Mappery, "Zambezi River Basin Map," available at http://mappery.com/map-of/Zambezi-River-Basin-Map.

Case Study 5: The Danube River (Europe)

The Danube River, Europe's second longest river, flows for 2,857 kilometers from the Alps to the Black Sea and drains a basin area of 817,000 km² in 18 riparian countries: Hungary, Romania, Austria, Slovenia, Croatia, Slovakia, Bulgaria, Germany, the Czech Republic, Moldova, Serbia, Ukraine, Bosnia and Herzegovina, Italy, Switzerland, Albania, and Poland[381] (see Figure B4). With over 81 million people living within its basin, the Danube is one of the most international river basins in the world.[382] While there have been 18 international agreements concerning the Danube since 1948,[383] the most progress on water quality has been made in the last 20 years through the Environmental Program for the Protection of the Danube River Basin (1991),[384] the Danube River Protection Convention (1994),[385] and the International Commission for the Protection of the Danube River (ICPDR) created by the Convention in 1998.[386] With these efforts and others, the "riparian states of the Danube River have established an integrated program for the basin-wide control of water quality which[…] has claims to probably being the most active and the most successful of its scale."[387]

Figure B4. The Danube River Basin Map

Source: Shmueli, Deborah F., "Water Quality in International River Basins," *Political Geography* 18, 1999, 437-476.

All of the riparian nations, as well as some interested international institutions within the Danube River Basin, met in Sofia, Bulgaria in September 1991 to develop a plan for protecting the Danube's water quality. What resulted was the establishment of the Environmental Program for the Danube River Basin to support and reinforce national action for the restoration and protection of the Danube River.[388] The meeting created a Task Force (the Task Force) composed of Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Romania, Slovakia, Slovenia, Ukraine, the European Commission, the European Bank for Reconstruction and Development, the European Investment Bank, Nordic Investment Bank, UNDP, UNEP, the World Bank, the Netherlands, the U.S., the World Conservation Union, WWF, the Regional Environmental Center, and the Barbara Guntlett Foundation.[389] The Task Force adopted a Program Work Plan and created the Program Coordination Unit to support the Task Force and monitor and coordinate the Program Work Plan. The Task Force established two "expert subgroups" to facilitate "principles of coordination and integration."[390] By 1993, the Task Force had created a Strategic Action Plan (SAP) to move from planning to implementation, in support of implementation of the Danube Convention of 1994.[391]

The Environmental Program for the Danube River is unusual because it includes international non-governmental organizations (NGOs) as Task Force members. It encourages public and NGO participation throughout the planning process to reduce confrontations or conflicts among countries.[392] It recognizes a "link between internal politics among different sectors and political constituents within a nation on the one hand, and the strength and resilience of an agreement reached in the international realm on the other."[393]

The Danube River Protection Convention is the legal instrument for co-operation on transboundary water management in the Danube River Basin. The Convention was signed on June 29, 1994 in Sofia by 11 of the Danube riparian countries and came into force in 1998. Its goal is to ensure that surface waters and groundwater within the Danube River Basin are managed and used sustainably and equitably.[394] The signatories have agreed to a series of actions including "the conservation, improvement and rational use of surface waters and groundwater, preventive measures to control hazards originating from accidents involving floods, ice or hazardous substances, measures to reduce the pollution loads entering the Black Sea from sources in the Danube River Basin,"[395] and "setting priorities as appropriate and strengthening, harmonizing, and coordinating measures taken and planned to be taken at the national and international level throughout the Danube Basin aiming at sustainable development and environmental protection of the Danube River."[396]

In 1996, the riparian countries approved a Strategic Action Plan (SAP) Implementation Program (SIP) to evaluate and analyze information collected by the SAP and implement SAP findings. In 1997, the Convention members created the Danube Pollution Reduction Program (DPRP) with the support of the UNDP Global Environmental Fund to define transboundary measures and actions, develop an investment program for national, regional and international cooperation, and control and reduce water pollution and nutrient loads in the Danube River and its tributaries.[397] Like the Environmental Program, the Convention was developed through public participation.[398] While the Convention outlines several cooperative measures to protect the waters of the Danube, it does not establish specific transboundary water quality standards. Instead, it gives a "general framework from which the signatories can devise appropriate water quality objectives and criteria."[399]

The International Commission for the Protection of the Danube River (ICPDR) incorporates stakeholder participation in all of its integrated river basin management planning. In 2003, the ICPDR set out to define the Danube River Basin Strategy for Public Participation in accordance with the 2000 EU WFD, which requires "four levels of public participation (see Table B4).

This concept of four levels of cooperation within an international river basin involving partners from the international to the local levels is the first of its kind. The ICPDR conducted a stakeholder analysis workshop to identify stakeholder groups on a Danube-wide scale as partners for information, consultation and active involvement. In 2005, the ICPDR invited stakeholders from all riparian countries to participate in the first basin-wide conference in Budapest to bring stakeholder groups together and serve as a stepping stone for future participatory initiatives.[400] Public participation within the management of an international river basin can facilitate greater cooperation between nations with regards to its water resources and it has "permitted the basin states of the Danube to move forward rather quickly with several initiatives."[401]

Table B4. Four Levels of Public Participation in the Danube River Basin

Level of Participation	Description
International	Among the basin countries
National	Implementation strategies and management plans within nations
Sub-Basin	Plans for pilot projects in different parts of the basin
Local	Assurance of where investment is actually implemented

Source: Priscoli, Jerome Delli and Aaron T. Wolf, *Managing and Transforming Water Conflicts*, New York: Cambridge University Press, 2009.

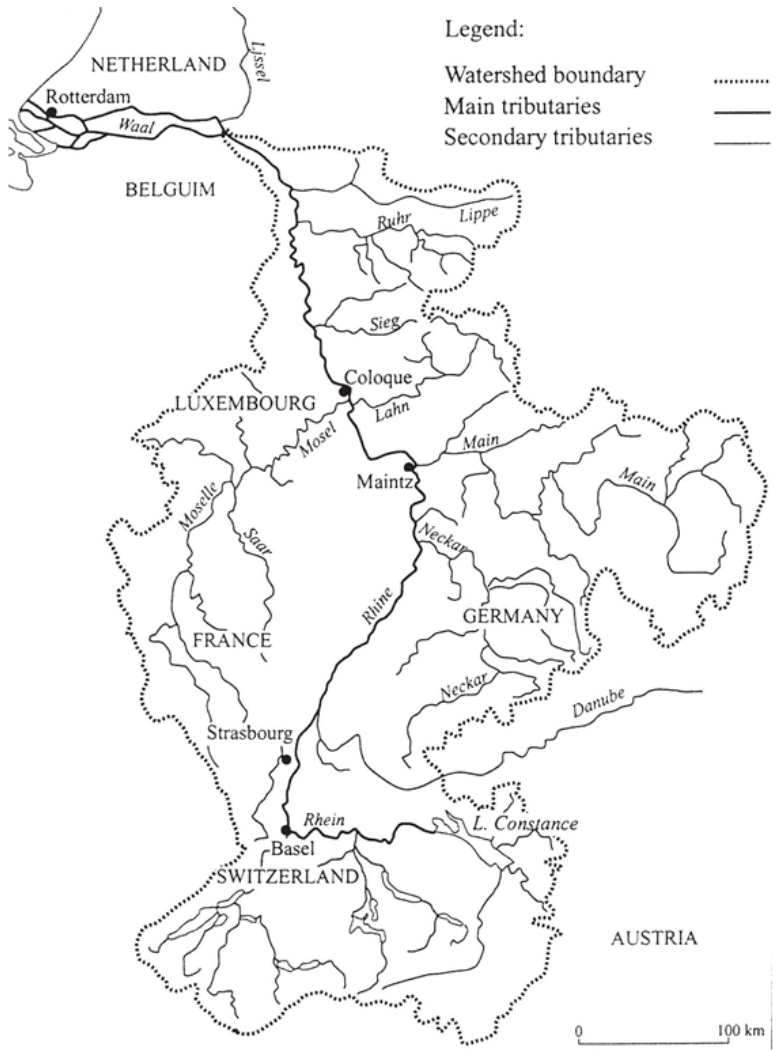
Case Study 6: The Rhine River (Europe)

The Rhine flows for 1233 kilometers from the Alps to the North Sea, and has always served as a cultural and economic axis in Middle Europe, as its waters are used more intensively than any other European rivers to support 58 million people are living in nine different states[402] (see Figure B5).

The Convention on the Protection of the Rhine (the Convention), the basis for international cooperation for the protection of the Rhine, was signed on On April 12, 1999 by representatives of five governments: France, Germany, Luxembourg, the Netherlands and Switzerland, as well as the European Community.[403] The Convention seeks to increase cooperation and to preserve, improve and encourage sustainable development within the Rhine ecosystem. Table B5 lists some of the objective of the Convention.

The parties to the Convention have made significant progress since 1999 in improving water quality (see Table B6). As a result, in January 2001, the ministers in charge of the Rhine adopted "Rhine 2020", the "Programme on the Sustainable Development of the Rhine" following the "Rhine Action Programme" (1987-2000). It determines the general objectives of the Rhine protection policy and the measures required for their implementation for the next 20 years.[404]

Figure B5. The Rhine River Basin Map



Source: Shmueli, Deborah F., "Water Quality in International River Basins," *Political Geography* 18, 1999, 437-476.

Table B5. Objectives of the Convention on the Protection of the Rhine

- Sustainable development of the Rhine ecosystem
- Continued use of the Rhine for drinking water production
- Improvement to the water quality of Rhine sediments so that dredged material may be deposited without causing environmental harm
- Prevention of flooding, taking into account ecological requirements
- Enhancement of the water quality of the North Sea

Source: International Commission for the Protection of the Rhine, "Convention on the Protection of the Rhine," accessed on Apr 20, 2012, available at http://www.iksr.org/index.php?id=33&L=3.

Table B6. Successes of the Convention on the Protection of the Rhine

1.	Water quality and the biological status of the Rhine and many of its tributaries have improved
2.	Almost 96 percent of the population are now connected to a wastewater treatment plant
3.	The number of animal and plant species has increased; at present, 63 fish species live in the Rhine
4.	Since 2006, salmon, sea trout and eel as well as other migratory fish may migrate from the North Sea as far upstream as Strasbourg
5.	Floodplains have been reactivated, oxbow lakes have been reconnected with the Rhine and tributaries, and in many smaller sections, the river bank structures have been ecologically improved
6.	Considerable efforts have been undertaken to reduce the negative impacts of flood events; additional flood retention areas have been created and almost all flood prevention measures planned in 1995 were achieved by 2005 at a cost of some 4.5 billion Euros

Source: International Commission for the Protection of the Rhine, "Convention on the Protection of the Rhine,"accessed on Apr 20, 2012, available at http://www.iksr.org/index.php?id=151&L=3.

Case Study 7: The Mekong River (Asia)

The Mekong River flows for 4,880 kilometers and includes a total land area of 795,000 km^2 (nearly the size of France and Germany together), with its basin including parts of China, Myanmar, and Vietnam, nearly one third of Thailand, and most of Cambodia and Laos (see Figure B6). The Lower Mekong River Basin drains four nations, Cambodia, Laos, Thailand and Vietnam, that includes approximately 60 million people. Over 100 different ethnic groups live within its boundaries, making it one of the most culturally diverse regions of the world.[405]

In 1995, the governments of Cambodia, Laos, Thailand and Viet Nam established the Mekong River Commission (MRC) through the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (the Agreement).[406] The parties agreed to jointly manage the shared water resources and to develop the economic potential of the river. The MRC consists of three permanent bodies: a Council, a Joint Committee, and the Secretariat. It is funded by contributions from the four member countries and aid donors. Formal consultation with the donor community is carried out through an annual Donor Consultative Group meeting.[407]

The MRC applies the principles of integrated water resources management to encourage balanced and coordinated investments in the areas of irrigation and drought management, navigation, hydropower, flood management, fisheries, watershed management, environment, tourism and environmental protection. Table B7 lists six of the Mekong River Commission's objectives:

Figure B6. The Mekong River Basin Map

Source: Shmueli, Deborah F., "Water Quality in International River Basins," *Political Geography* 18, 1999, 437-476.

Table B7. Mekong River Commission Objectives

- Improve monitoring of the environmental state of the basin, focusing on water quality, ecological health and social development
- Increase environmental and socio-economic knowledge in the Mekong River basin
- Improve the dissemination and accessibility of environmental information (within the basin and between the basin and elsewhere)
- Ensure that social, economic and ecological concerns are incorporated in basin-wide environmental policies and procedures (in line with Article 3 of the 1995 Agreement)
- Improve awareness and capacity of MRC and riparian government personnel to address transboundary and basin-wide environmental issues
- Ensure that development initiatives are planned and implemented with a view to minimize negative environmental impacts in the Mekong River Basin

Source: Mekong River Commission, "Mekong River Commission Objectives," accessed on Oct 9, 2011, available at http://www.mrcmekong.org/programmes/environment.htm.

The MRC encourages "reasonable and equitable use"[408] of the Mekong River system through a participatory process with National Mekong Committees in each country. The MRC is supporting the Basin Development Plan, a joint, basin-wide planning process within the four countries. The Plan seeks to integrate the integrated water resources development principles and "participatory planning"[409] involving an expanded range of stakeholders. The MRC has developed a hydropower strategy based on principles that recognize the rights and needs of multiple users, the value of public participation in planning, and protection of the environment.[410] The Mekong Committee has an "impressive record of continuing its work throughout intense political disputes between riparian countries" and "data conflicts have not been a factor in the Mekong," unlike in many other basins. This case "may suggest that when international institutions and organizations are established well in advance of water stress," they help to prevent conflict and facilitate "joint management and dispute resolution."[411]

Endnotes

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[337] Ibid.

[338] Lopez, *Environmental Conflicts,* 16.

[339] Commission Trinacional del Plan Trifinio, “Treaty between the Republics of El Salvador, Guatemala and Honduras for the Implementation of the Plan Trifinio,” trans. Google Chrome, available at http://www.sica.int/busqueda/Centro%20de%20Documentaci%C3%B3n.aspx?IDItem=1302&IdCat=10&IdEnt=140&Idm=1&IdmStyle=1.

[340] Ibid.

[341] Lopez, *Environmental Conflicts*, 18.

[342] Commission Trinacional del Plan Trifinio, Trifinio Plan Update 2004, trans. Google Chrome, available at http://www.sica.int/busqueda/busqueda_archivo.aspx?Archivo=info_5241_4_10052006.htm.

[343] Ibid.

[344] Commission Trinacional del Plan Trifinio, “Promoting Water Management and Regional Public Goods in the Upper Lempa River Basin Region Trifinio,” trans. Google Chrome, available at http://www.sica.int/busqueda/Proyectos.aspx?IDItem=8673&IDCat=23&IdEnt=140&Idm=1&IdmStyle=1.

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[352] World Bank, Project Information Document (PID), Lake Victoria Environmental Management Project II, Report No. AB5110, March 10, 2010, available at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/03/17/000262044_20100319104753/Rendered/PDF/Project0Inform1oncept0Stage01Final1.pdf.

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[356] World Bank, “Lake Victoria Management Project,” accessed October 7, 2011, available at http://water.worldbank.org/water/projects-and-operations.

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Appendix C. GIS Mapping in the Lower Rio Grande/Río Bravo

This chapter present the preliminary geo-spatial analysis of water quality and water infrastructure and allows a way to identify trends in water quality impairments within the Lower Rio Grande watershed. By mapping water quality and infrastructure investment from 2007 through 2012, areas of persistent water quality impairments can be identified. Overlaying this time series data with data on binational wastewater infrastructure investment provides a snap shot of how effectively investments have targeted the areas of concern.

This study also examines the connection between infrastructure investment and water quality. Previous scholarship has reported a positive relationship between binational, federal, and state expenditures and improved water quality in the Arroyo Colorado Watershed in South Texas.[412] Over the past six years, the North American Development Bank (NADB), the Border Environment Cooperation Commission (BECC) and the Texas Water Development Board (TWDB) have administered various financial assistance programs in excess of $152.9 million dedicated to improving water quality in this region. This paper consolidates investment data and compares expenditures with water quality monitoring levels for effluent indicators such as E. coli. This study uses geographic information systems (GIS) to depict where and how binational, federal, and state expenditures are being used to improve wastewater infrastructure in South Texas.

Table C1 lists the completed water quality infrastructure projects on both the Mexican and U.S. sides of the Rio Grande/Rio Bravo during the period of 2007 through 2013. These projects affect river water quality by either preventing wastewater or polluted water flows into the river or by collecting and treating wastewaters before they are discharged into the river. Figures C1 through C6 illustrate average measured E. coli levels along the river from Falcon Dam to the Gulf from 2007 (Figure C1), 2008 (Figure C2), 2009 (Figure C3), 2010 (Figure C4), 2011 (Figure C5), and 2010 (Figure C6). Each of these E. coli figures represent mean annual most probably number (MPN) of colonies of E. coli, as measured among any of the 23 water quality monitoring stations along the river. Figures C7 through C12 graph average total dissolved solids (TDS) levels along the river from Falcon Dam to the Gulf from 2007 (Figure C7), 2008 (Figure C8), 2009 (Figure C9), 2010 (Figure C10), 2011 (Figure C11), and 2010 (Figure C12). Each of these TDS figures represent mean annual total dissolved solids in river water, measured in milligrams per liter among any of the 23 water quality monitoring stations along the river. Figure C13 overlays the total investment in water quality infrastructure in communities along the border, as enumerated in Table C1, with the relative E. coli levels measured in the river during 2007 through 2012. (All figures were developed by members of the 2012-2013 Rio Grande Water Quality Project.)

Table C1. Completed Water Quality Investment Projects

Authority Name	Project Name	County Name	Sum of Commitment Amount	Comple-tion Date	Programs	Latitude	Longitude
Roma	Water and Wastewater System Expansion	Starr	37339875.00	12/4/2007	CWSRF/CWTAP/DWSRF/EDAP/WDF	26.407085	-99.019651
Roma	Water System Upgrades	Starr	5385999.79	12/4/2007	CWTAP/EDAP	26.407085	-99.019651
Roma	Improvements and Expansion of the Water Supply and Wastewater Systems	Starr	4980000.00	12/1/2009	NADBANK	26.407085	-99.019651
Roma	SB 1421 Wastewater Improvements	Starr	5064596.71	8/11/2010	CWTAP/EDAP	26.407085	-99.019651
Rio Grande City	Surface Water Treatment Plant	Starr	20900000.00	9/11/2012	DWSRF	26.375896	-98.812859
Mata-moros	Comprehensive Water and Wastewater Project (First Phase)	Tamaul-ipas	32970000.00	8/1/2008	NADBANK	25.876369	-97.506437
Reynosa	Comprehensive Sanitation Project	Tamaul-ipas	33500000.00	5/1/2011	NADBANK	26.079913	-98.297825
Río Bravo and Neuvo Progreso	Water Distribution and Wastewater Collection and Treatment Plant	Tamaul-ipas	12760000.00	12/1/2013	NADBANK	26.055356	-97.948805

Figure C1. E. coli Levels in 2007

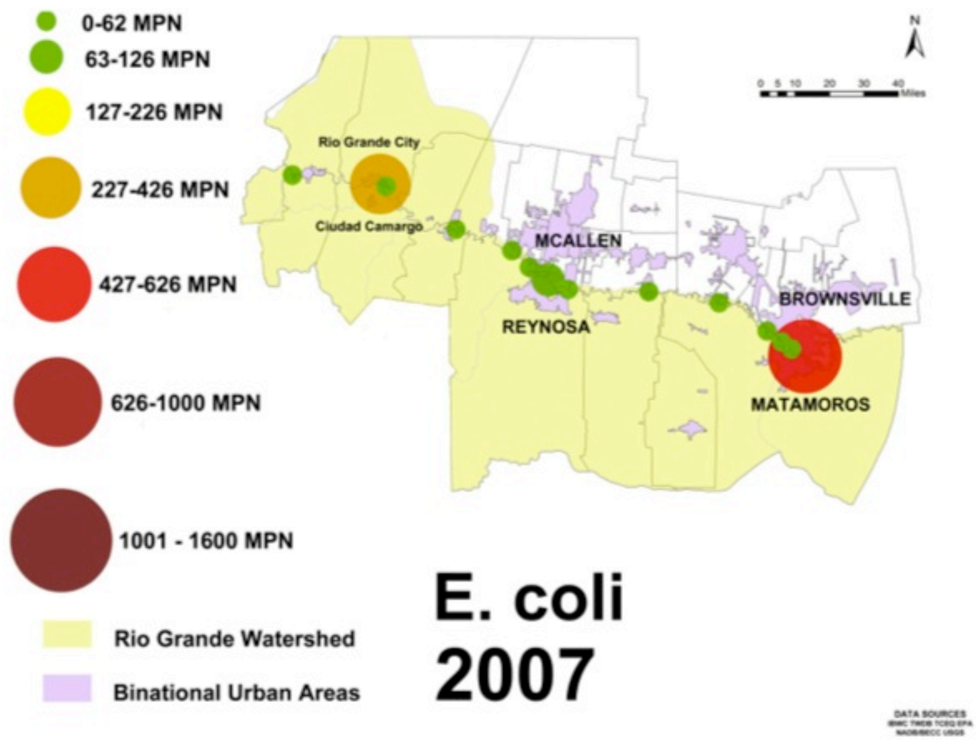


Figure C2. E. coli Levels in 2008

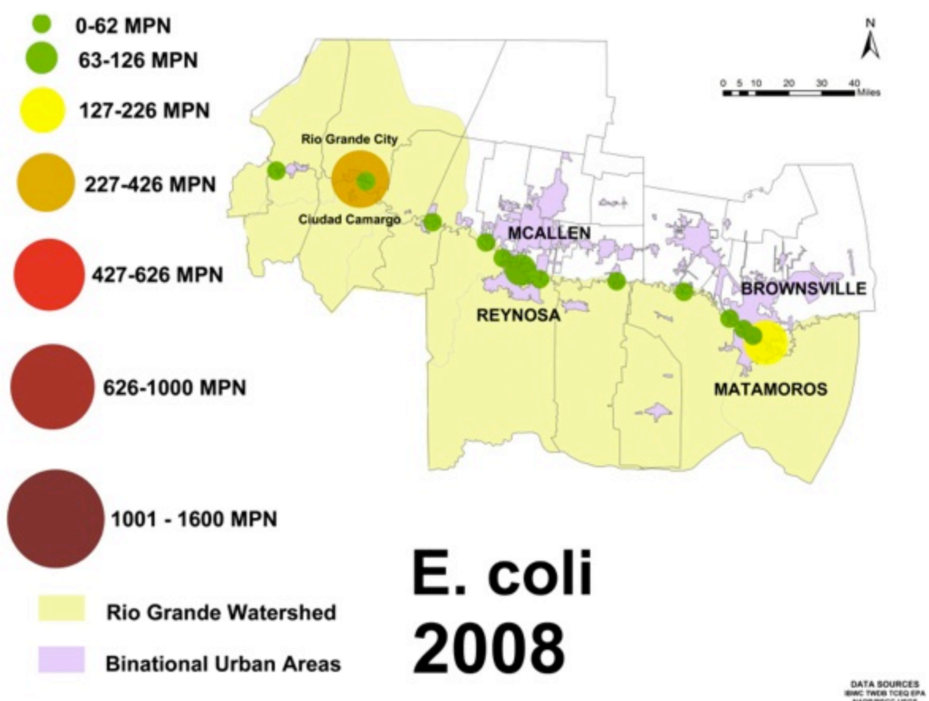


Figure C3. E. coli Levels in 2009

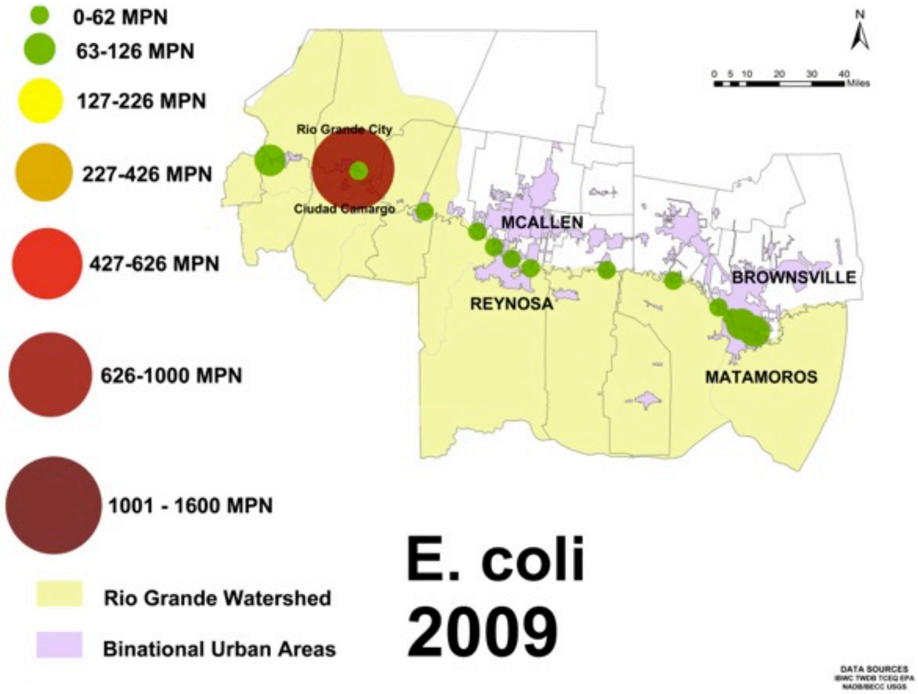


Figure C4. E. coli Levels in 2010

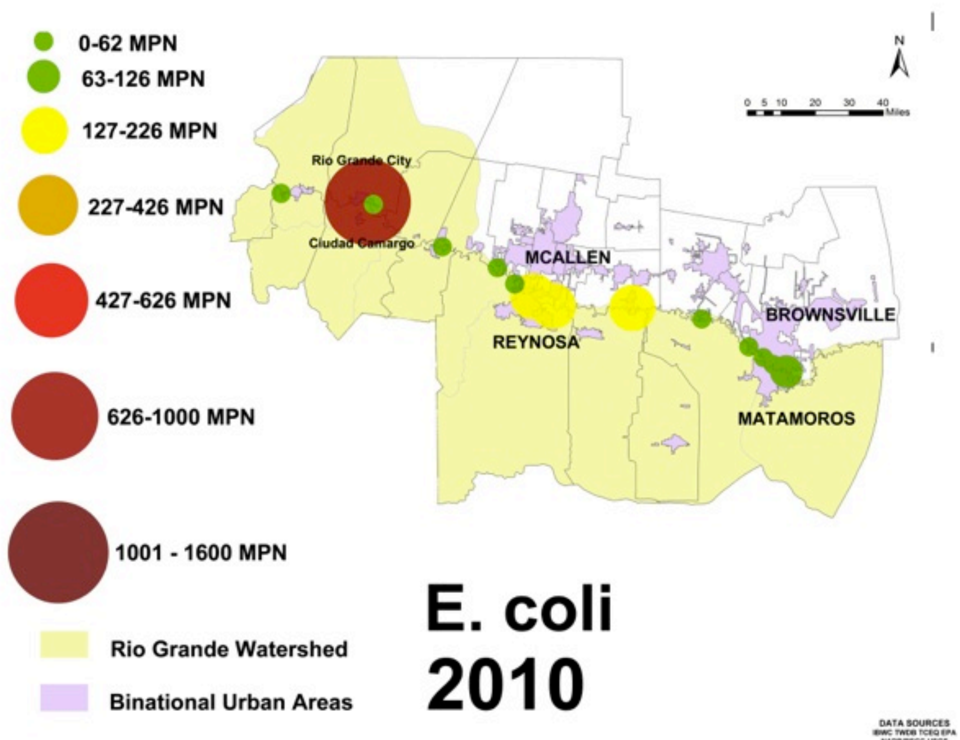


Figure C5. E. coli Levels in 2011

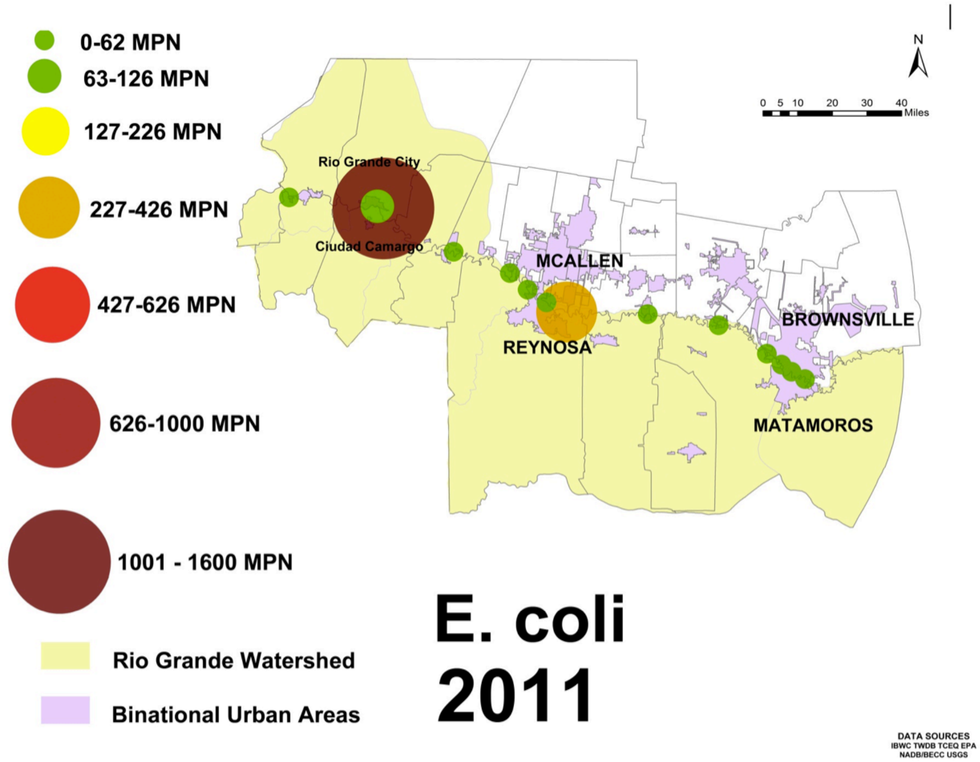


Figure C6. E. coli Levels in 2012

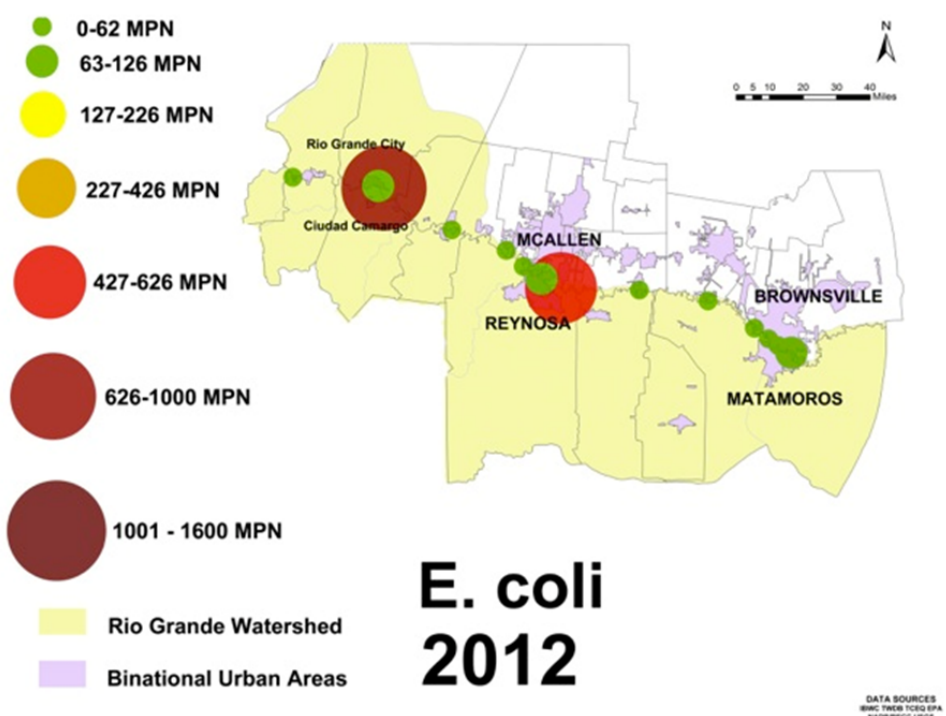


Figure C7. Total Dissolved Solids Levels in 2007

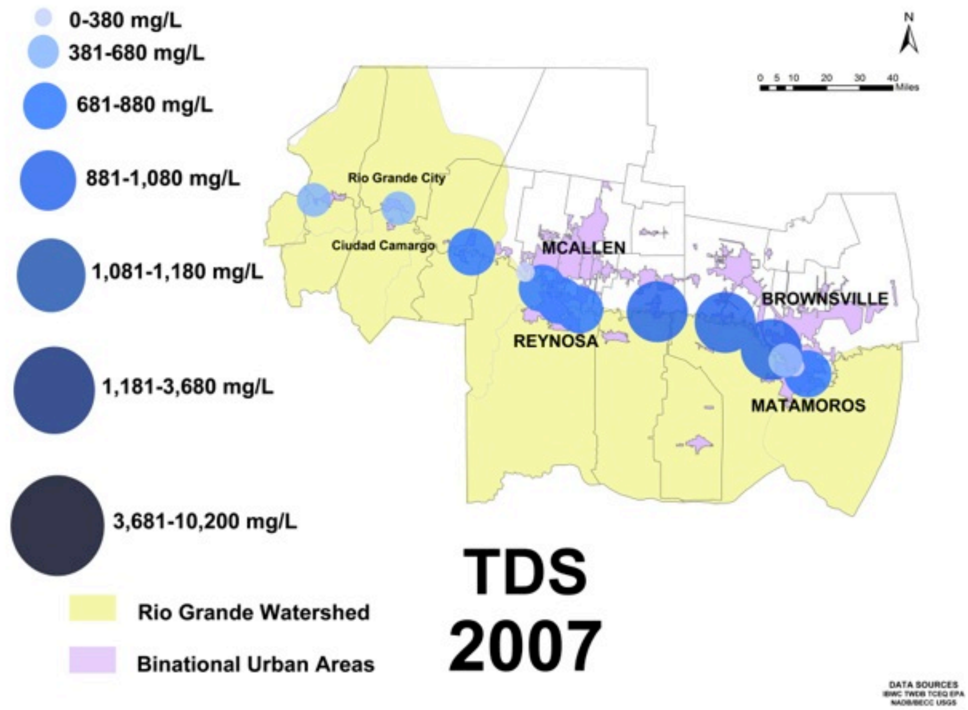


Figure C8. Total Dissolved Solids Levels in 2008

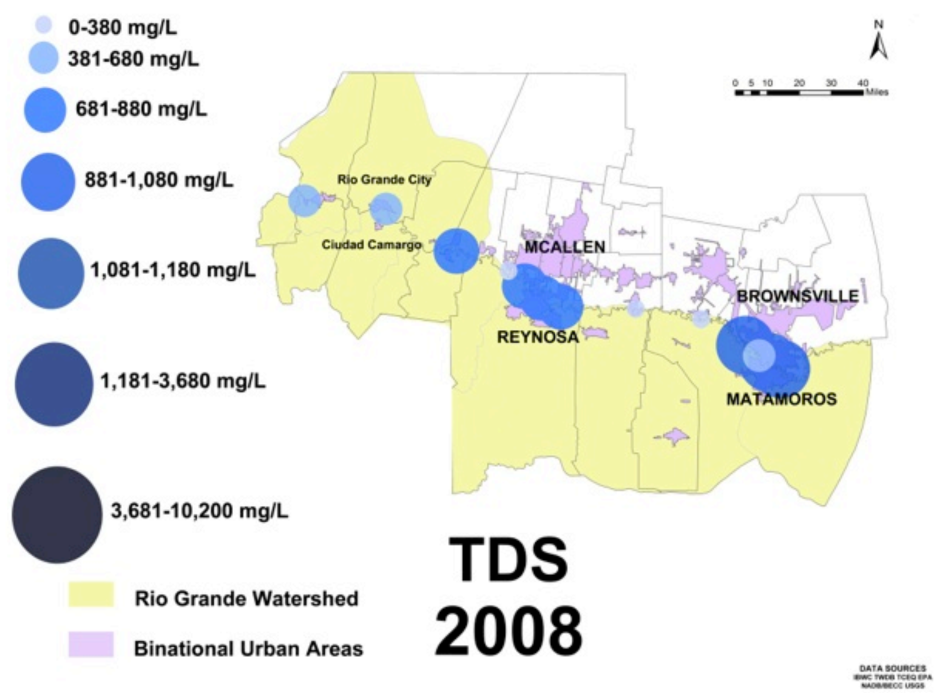


Figure C9. Total Dissolved Solids Levels in 2009

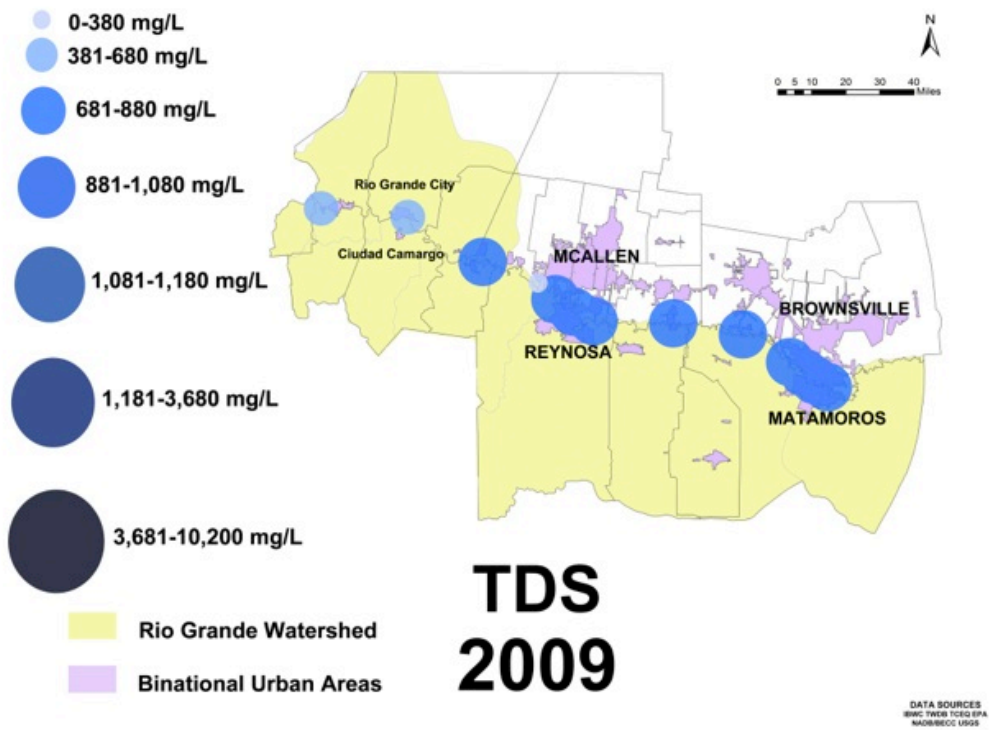


Figure C10. Total Dissolved Solids in 2010

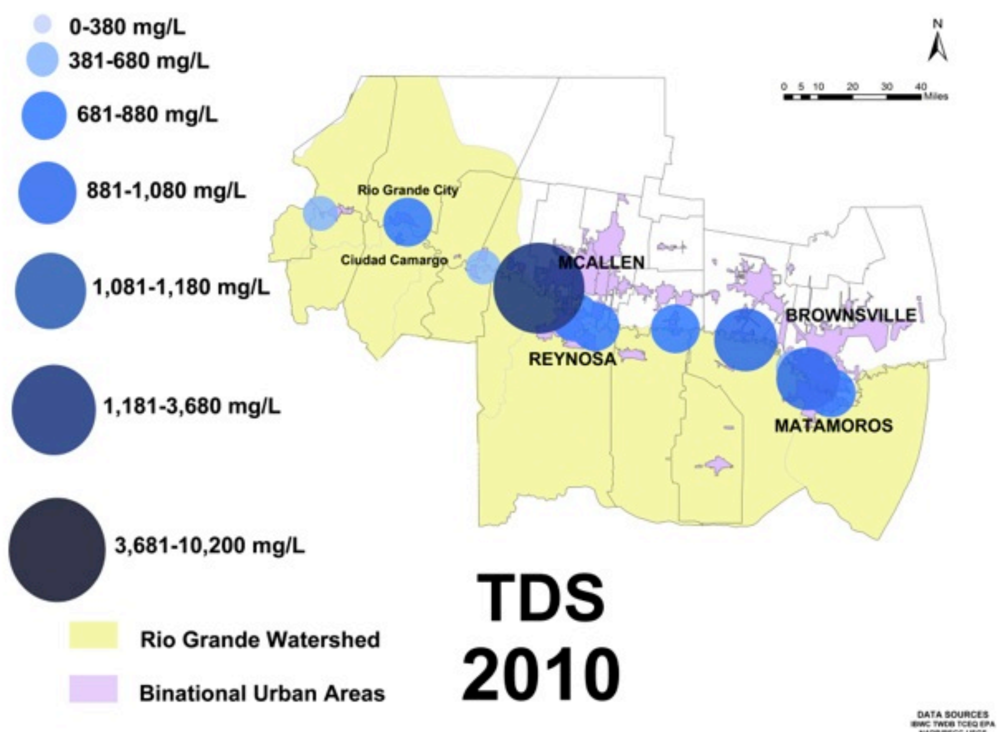


Figure C11. Total Dissolved Solids Levels in 2011

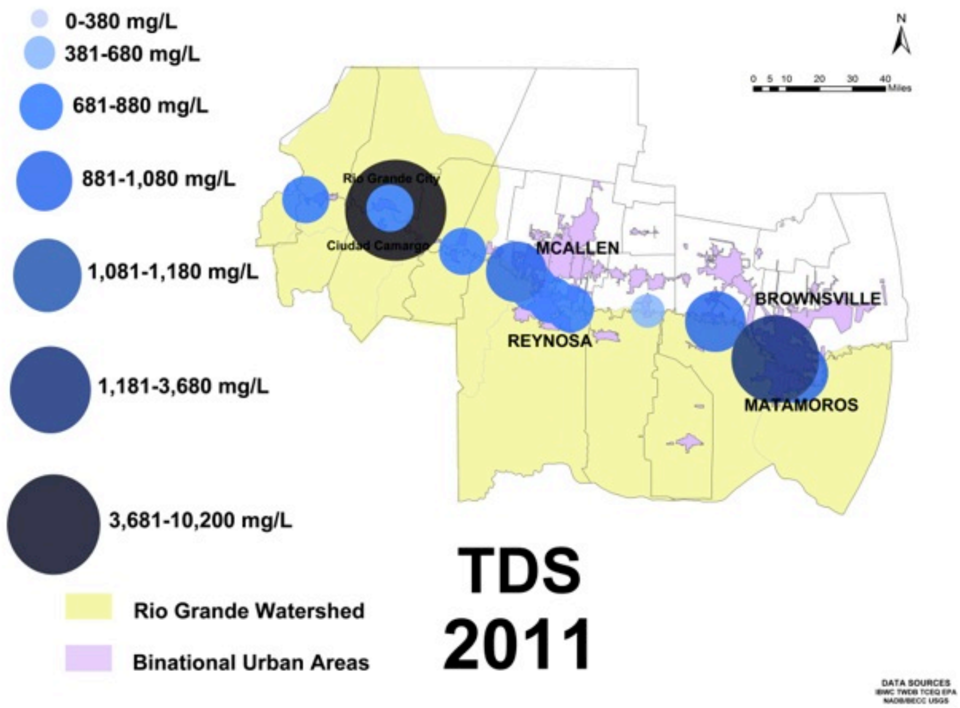


Figure C12. Total Dissolved Solids in 2012

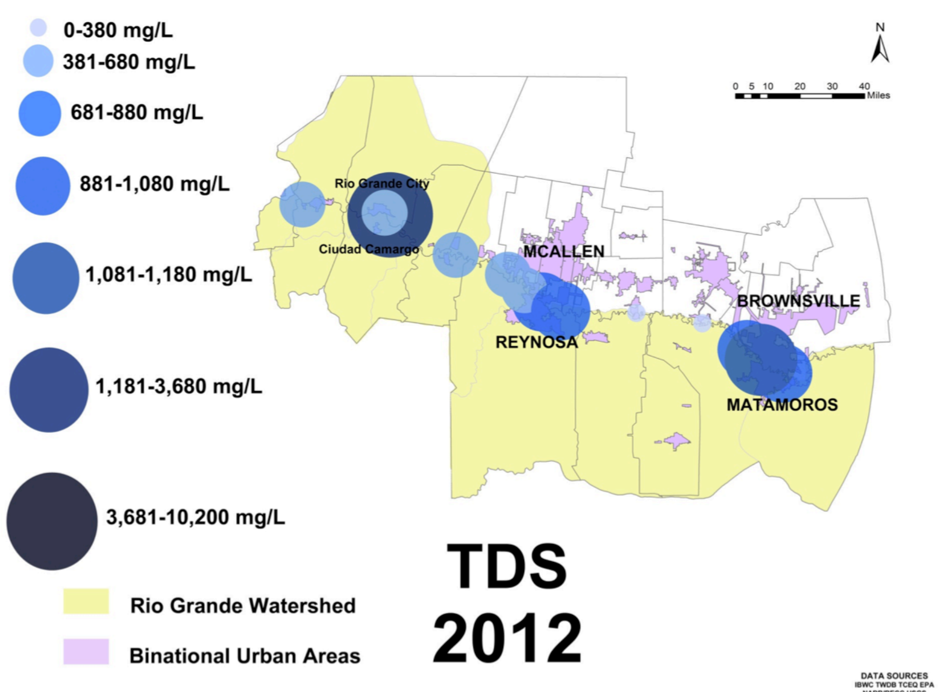
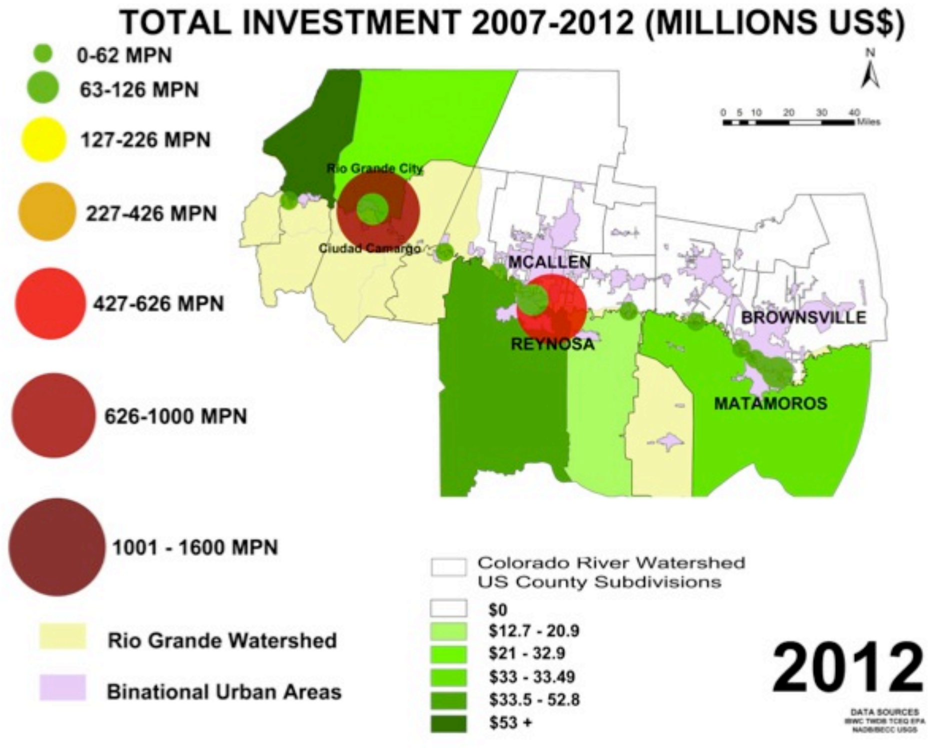


Figure C13. Total Investment with 2012 E. coli Levels



Pollution Levels

This study relies on two pollution indicators, E. coli and Total Dissolved Solids (TDS)/Salinity, and utilizes the Texas Surface Water Quality Standards for both. The Texas Clean Rivers Program (TCRP), which publishes the data from the IBWC and TCEQ river monitoring systems, identified these contaminants as issues in the Lower Rio Grande below Falcon Dam.[413] This analysis compiled water monitoring station data from 2007-2012. The TCRP data was transposed into separate spread sheets for each year of study. When a particular monitoring station recorded multiple measurements throughout the year, staff calculated an average level for the year; a geometric mean was calculated for E. Coli and an arithmetic mean for TDS. Not all monitoring stations measured both E. coli and TDS each year. Missing data were left blank, explaining why some stations do not appear on each yearly maps.

Researchers used ArcGIS to construct a base-map consisting of the three U.S. counties (Cameron, Hidalgo, and Starr) and the north section of the Mexican state of Tamaulipas. U.S. counties were broken into sub-counties and Tamaulipas was broken into its municipios (municipalities). The Rio Grande watershed was then overlaid on this base-map. Only areas contained within the watershed are of interest to this study as discharge from those areas contribute to E. coli and TDS levels. This excludes nearly all of Cameron and Hidalgo counties. A shapefile of urban areas was added to the map to graph potential sources of the pollution, whether it be from septic tank overflows from a densely populated area or agricultural run-off from rural sites.

Staff plotted the geographic location of each of the IBWC monitoring stations to represent yearly E. coli and TDS averages graphically. Staff developed graduated and color-coded symbols for monitoring stations, so as concentration levels increase, the size of the monitoring station point increases, quickly communicating which areas are above U.S. standards. E. coli levels are coded as red, yellow, or green based on their severity. Levels below the U.S. standard of 880 parts per 100 ml are green (although they are still scaled by size with the largest green points just at or below the standard). Monitoring stations whose yearly average was between 127-426 colonies per unit (MPN) / 100 ml were coded two shades of orange, while the highest concentrations, 427-1600 colonies per unit (MPN) / 100 ml, were coded red. TDS levels were shown in blue with larger and darker points indicting higher levels. The three smallest sizes are at or below the U.S. standard of 880 mg/l.

Investment in Water Quality Infrastructure

This project chose to include infrastructure investment only when the purpose of the project was wastewater treatment, the project was completed between 2007 and 2012, and the project was located within the Lower Rio Grande/Río Bravo watershed. Researchers compiled data from the NADBANK, the BECC, the TWDB, and CONAGUA (see Table C1). Of the available data, only seven projects fit the criteria.[414] This research is preliminary and additional investment may have been conducted in the area of study which is not yet reflected in this project. This data set excludes projects currently under construction.

Researchers used ArcGIS to locate the projects within the sub-regions of the study area. One spreadsheet was created which included all projects. Those data were added to the 2012 E. coli map and includes all investment completed from 2007 onwards. As these projects are not expected to influence salinity, they do not affect the salinity map series. Sub-counties and municipios with investment were color coded in green, with darker hues indicating higher levels of investment. For those areas in which investment appeared to be related to changes in E. Coli levels, further qualitative research was undertaken to understand the types of investment and their efficacy.

E. Coli: Results and Discussion

The Texas and U.S. limit for E. coli is at or below 126 colonies per unit (MPN). Stations meeting this standard are shown in green. Stations above the standard are shown in yellow, orange, and red in relation to the severity of the monitored levels. 2007 E. coli levels were above the U.S. standard at Station 13185 near Rio Grande City and Cuidad Camargo (360 MPN) and Station 13177 downstream of Brownsville and Matamoros (607 MPN). All other stations showed at standard average levels.

2008 data show a decrease in E. coli levels at Station 13177 downstream of Brownsville and Matamoros (182 MPN). Though still above the U.S. Surface Water Quality Standards, levels decreased to less than one third of its previous value. Levels at the other stations remain the same with Station 13185 continuing to record high levels (362 MPN).

2009 data indicate an increase in E. coli levels at Station 13185 to 785 MPN. However, levels in the Brownsville/Matamoros area stayed below the U.S. legal limit for the first time in this study. This station continues to meet the standard through 2012.

In 2010, E. coli levels continue to increase at Station 13185 reaching an average of 852 MPN. Additional problems arise at Stations 13181 (221 MPN), 15808 (173 MPN), and 17247 (130 MPN) in the McAllen/Reynosa area. Previously, these stations had all met the U.S. standards.

In 2011, Station 13103 records the highest levels of E. coli to date: 1549 MPN. However, the stations directly upstream and downstream register at standard levels. In the McAllen/Reynosa area, only Station 15808 registers levels above standard, but the level is higher than the previous year at 245 MPN.

In the final year of study, the problematic E. coli levels continue at Station 13103 (741 MPN) near Rio Grande City and Ciudad Camargo and Station 15808 (434 MPN) at McAllen/Reynosa. Stations on either side register below U.S. standards.

E. coli levels are persistently over the U.S. legal limit the Rio Grande City/Ciudad Camargo area. E. coli is becoming a persistent problem in the McAllen/Reynosa area, with levels registering above the U.S. surface water quality standard for the past three years. However, E. coli levels have been brought below the U.S. standard in the Brownsville/Matamoros area. This decrease may be due, in large part, to the construction of a wastewater treatment plant in Matamoros that began to operate in 2008. That project is discussed in greater detail in the investment section of this report.

Total Dissolved Solids: Results and Discussion

Total Dissolved Solids is a measure of the river’s salinity level. The Texas Clean Rivers Program has identified salinity as a concern in the Lower Rio Grande. This analysis compiles data on TDS levels to verify the concern. The U.S. standard for TDS is at or below 880 mg/L. Stations are shown in varying shades of blue with larger sizes and darker shades indicating higher levels.

The 2007 data for Total Dissolved Solids (TDS) indicate only a moderate problem with salinity levels at Station 10249 (979 mg/L) and Station 17247 (920 mg/L). Both stations are located downstream in the Brownsville/Matamoros area.

The 2008 data continue to show readings exceeding the U.S. standard in the Brownsville/Matamoros area at three stations: Station 13179 (915 mg/L), Station 13178 (1010 mg/L) and Station 13177 (930 mg/L).

The 2009 TDS data indicate a healthy river with all stations in the Lower Rio Grande/Río Bravo registering at or below the U.S. standard of 880 mg/L. Even those stations in the Brownsville/Matamoros area meet the standard.

TDS levels increase in 2010 and starting in 2010, salinity has become an issue in McAllen/Reynosa in addition to Brownsville and Matamoros. Three stations register above standard levels: Station 20698 in the McAllen/Reynosa area (3680 mg/L), Station 10249 (890 mg/L) and Station 20449 in the Brownsville/Matamoros area (902 mg/L).

The 2011 data show five stations registering TDS levels above the U.S. standard. Stations 20449 (1524 mg/L), 13178 (892 mg/L) and 10249 (994 mg/L) in Brownsville/Matamoros are significantly above the limit. Station 20698 in McAllen/Reynosa remains just above limit at 890 mg/L. Station 13103 near Rio Grande City/Ciudad Camargo registered 10,200 mg/L (over 11 times the U.S. standard), although this reading is not an average but the only reading recorded for 2011. Texas' severe drought may be a contributing cause of increasing salinity levels.

The close of 2012 show average TDS levels exceeding the U.S. standard at seven stations: four in Brownsville/Matamoros, two in McAllen/Reynosa, and one in Rio Grande City/Ciudad Camargo. Station 13103 in Rio Grande City remains significantly over the limit at 2,115 mg/L. Two Brownsville/Matamoros stations also exceed 1,000: Station 20449 (1,089 mg/L) and Station 13178 (1,067 mg/L). The remaining two in Brownsville/Matamoros only slightly break the standard: Station 13179 (894 mg/L) and Station 13177 (886 mg/L). Two stations in McAllen/Reynosa also remain above the standard: Station 13181 (889 mg/L) and Station 15808 (938 mg/L).

These salinity level measurements over time indicate increasing levels across the Lower Rio Grande/Río Bravo basin. While only two stations registered higher than standard levels in 2007, seven stations were above the Texas Surface Water Quality Standard of 880 mg/L in 2012. There was a spike in 2011, with TDS levels in Rio Grande City rising as high as 10,200 mg/l. The extended drought may be a precipitating factor in rising salinity levels; however, it is clear that the problem is spreading.

Investment in Water Quality: GIS Analysis

Although there has been considerable investment in wastewater systems between 2007 and 2012, only in the Brownsville/Matamoros area has this investment corresponded with decreasing E. coli levels. The instillation of a wastewater treatment plant in Matamoros which came online in 2008 may be a primary cause of this improvement in water quality. Further qualitative research is needed in the types of projects completed in each area in order to try to ascertain why water quality concerns remain prevalent, even after investment in water quality infrastructure.

Matamoros Comprehensive Water and Wastewater Project (First Phase)

The sum of NADBANK grant funding for the Matamoros project was $32,969,182.[415] Prior to the installation of this project, 75 percent of the city of Matamoros received wastewater collection; however, there was no wastewater treatment. All wastewater was discharged into the Rio Grande untreated. This project included rehabilitation and expansion of the water treatment plant, construction of a new wastewater treatment plant, construction and rehabilitation of water distribution and wastewater collection systems, and the installation of micrometers.[416]

Río Bravo and Nuevo Progreso Water Distribution and Wastewater Collection and Treatment Project

NADBANK provided $12,760,000 in grants to support the Río Bravo and Nuevo Progreso project.[417] Río Bravo and Nuevo Progreso contribute effluent to the Rio Grande/Río Bravo watershed due to limited water and wastewater connections for residents, as 66 percent of residents in Río Bravo and 30 percent of residents in Nuevo Progreso are connected to wastewater collection systems. Prior to this project, their wastewater collection facilities discharged untreated wastewater into the basin. This project increased wastewater capacity by: constructing a lagoon-based wastewater treatment plant, constructing conveyance systems to carry wastewater from each community to the plant, expanding and rehabilitating the wastewater collection systems, and expanding and rehabilitating the Río Bravo water system. Aside from a spike in E. coli levels in 2010, levels have generally remained below the U.S. upper limit and levels downstream in Brownsville/Matamoros have been decreasing. This could point to the efficacy of this project in decreasing ambient E. coli levels.[418]

Reynosa Comprehensive Sanitation Project

NADBANK provided $33,500,000 in grants to support the Reynosa project.[419] Approved in 1998, this project is divided into four phases to be completed over a twenty year period. It addresses the continuing challenges of untreated wastewater disposal from the city of Reynosa. At the start of the project, only 57 percent of Reynosa households were connected to sewer services and one in four lots with sewer connections were not connected and disposed of sewage through septic tanks and cesspools. Despite not reaching the entire city, the Reynosa treatment plant had met capacity and was dispensing untreated or partially treated effluent into the Rio Grande. The Comprehensive Sanitation Project addresses these problems by: constructing a new wastewater treatment plant, rehabilitating the existing wastewater treatment plant, and constructing and rehabilitating the sewer system and pump stations. The lack of significant improvements may indicate only the first phase completion of the program.

Roma Improvements and Expansion of the Water Supply and Wastewater Systems

NADBANK provided $4,980,000 in grants to support the Roma project.[420] Nearly three in four residents were not connected to a wastewater treatment facility and used septic tanks. This project improves the water distribution system through installing of 52,000 linear feet of distribution lines to replace and supplement existing lines, enhancing the booster station, constructing a 200,000 gallon elevated water storage tank, expanding the water treatment plant from 1.5 million gallons per day to 5.15, and purchasing additional water rights in anticipation of increased demand. This project extends sewer service to

3,688 households through the following measures: constructing a new 2 mgd wastewater treatment plant, installing 380,000 linear feet of sewer pipe and 100,000 feet of sewer force main, installing 22 lift stations, adding a System Control and Data Acquisition system, constructing 3,688 sewer connections, and decommission existing sewer tanks. The continuing problem with E. coli levels downstream of Roma may indicate that this project is still struggling to reach all residents or that non-point sources of pollution (agriculture, wildlife) pose a significant part of the problem.[421]

Roma Water System Upgrades

Prior to NADBANK's Roma project, the Texas Water Development Board and other organizations invested $47,790,471 in three Roma water system projects.[422] The Roma water system had been rated substandard in water treatment, storage, and distribution capacity. The majority of the project focuses on households utilizing septic tanks and cesspools outside of the city center. The water system upgrades include: providing service to 5,190 existing households, providing wastewater connection lines in colonias, and expanding Roma's wastewater treatment plant.[423]

Rio Grande City Surface Water Treatment Plant

Limited information is available regarding the construction of the Rio Grande City surface water treatment plant. As surface water treatment is focused on distributing clean drinking water, this project has less impact on pollution emitted into the Rio Grande watershed.[424] The total cost of the project is US$ 20,900,000 through grants from the DWSRF.[425]

Conclusion

All the represented projects address sources of direct contamination by improving the quality of discharged wastewater and by increasing connections to wastewater and water systems and decreasing the use of unregistered septic systems and cesspools. Major investments in expanding and rehabilitating wastewater treatment facilities, particularly on the Mexican side of the border, have moderately improved water quality. However, monitoring station data indicate that E. coli and TDS levels remain as problems in the Brownsville/Matamoros, Reynosa/McAllen, and Rio Grande City areas despite this investment. These projects do not control non-point source contamination, even though nonpoint source pollution has been identified as a water quality concern within the Rio Grande Valley.[426]

Endnotes

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